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**SHERIDAN TECHNICAL ASSOCIATES INC.**

Consulting Research Laboratory Services

EVALUATION OF HEAVY OIL RECOVERY  
PROCESS USING A NOVEL  
COMBINATION OF INJECTANTS

FINAL REPORT

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## OBJECTIVE

The objective of this research proposal is to improve the recovery, and the economics of recovery, of heavy oil from the reservoirs of Alberta and Saskatchewan. It is estimated that only about two percent of the Canadian heavy oil resource is amenable to production by present day technology; and as much as half of this oil is normally left unrecovered.

The CANMET Energy Research Laboratory Annual Report (1985/1986) identifies a critical gap in the development of both thermal and non-thermal in-situ processes for marginal Canadian heavy oil reservoirs which are characterized by thinness, presence of bottom water and gas caps. The report also emphasizes the need for the evaluation of additives and ways in which they may be used to enhance displacement efficiency.

This research program addresses the above concerns. The project aims specifically at assessing a new thermal heavy oil recovery process which uses a unique combination of hot water, non-condensable gas and interfacial additives. The study demonstrates how gas and interfacial additives combined may improve both the displacement efficiency and the economics of the thermal process. Because of its relative simplicity and low cost, the promising results of this study could lead to early implementation of the process in the field.

A comprehensive, statistically designed experimental program has been followed in evaluating the process. Specific areas of study include:-

- . Comparative laboratory displacement tests of the hot water/non-condensable gas process with normal steam drive.
- . Examination of the effect of operating variables on the efficiency of the hot water/non-condensable gas displacement process.
- . Assessment of the effect of gas solubility, in the oil, on the efficiency of the water/gas drive process.
- . Investigation of the role of interfacial additives in the water/gas drive process.

## JUSTIFICATION

The vast Canadian heavy oil resource presents a major economic opportunity for the Western provinces and an important source of energy for Canada. Despite some isolated, successful heavy oil recovery projects, it is now becoming recognized that the oil industry still faces formidable technical challenges in developing this resource. The nature of the Canadian heavy oil (high viscosity and specific gravity) and the varied nature of the Canadian reservoirs (thin and heterogeneous pay-zones) make this massive resource elusive to recovery by established steam and in-situ combustion techniques. Moreover, carbonate reservoirs, common in Alberta, and ill-defined sand bodies, prevalent in Saskatchewan, present the oil industry with particular problems it has not encountered before.

The need for research and development of modified thermal processes, suited for Canadian reservoir conditions, is being stressed. Thus, new strategies for steam injection are being suggested. One strategy, for example, attempts at confining steam to either the top, middle or bottom of the formation. This is being done by taking advantage of gas caps, high permeability zones, thin bottom water layers, or by drilling horizontal wells. Other suggestions for controlling steam zones include selective injection of hot water, gas, chemical additives, or modifying the injection-production schemes.

Of the non-thermal methods, immiscible carbon dioxide flooding appears to show potential for some Canadian heavy oil reservoir conditions. The process is known to be independent of the pay-zone thickness (in contrast to the high heat losses associated with steam injection in thin formations). It is also relatively insensitive to reservoir heterogeneity.

A new heavy oil recovery process which combines hot water and gas drive has been recently suggested. It appears to offer certain advantages which make it particularly attractive for Canadian reservoir conditions. First the high heat losses, from the steam zone to the overburden in thin formations, are eliminated by use of gas. The relative insensitivity of gas flow to reservoir heterogeneity is another advantage. In addition to these specific advantages, the new recovery technique could improve on the economics of steamflooding by eliminating steam generation equipment and costly water treating systems. Adding an interfacial agent to the water/gas drive has potential for further improvement to heavy oil recovery.

The new hot water/gas process has been described in only one reference in the open literature. In that reference, no systematic statistical assessment of the data, and consequently the process, was offered. Furthermore, we are not aware of any testing of the process with Canadian crudes. Finally, the process was only tested for a combination of hot water and inert gas (nitrogen). Other gases, such as  $\text{CO}_2$ , can offer additional advantages which have not been considered. Previous studies show that the use of interfacially active agents with steam can enhance oil recovery. It is proposed that these types of additives also be evaluated for application in the hot water/gas process.

The proposed research program puts forward a comprehensive, statistically designed, experimental study to evaluate these processes for representative heavy crudes from Alberta and Saskatchewan.

## SUMMARY

A laboratory study of the displacement of heavy oil by a combination of hot water and gas has been undertaken. The study was based on bench scale, non-scaled, core displacement experiments. Two heavy oils, one from Alberta (Pelican Lake) and the other from Saskatchewan (Buffalo Coulee), were employed. The effect of a range of operating variables (injection temperature, water injection rate, gas injection rate and back pressure) and interactions (oil/gas/permeability interactions and oil/additive/connate water salt concentration) have been investigated. The potential roles of a soluble gas ( $\text{CO}_2$ ) and of interfacial additives (Sodium hydroxide and a petroleum sulfonate additive TRS 410) have been evaluated. The Hot Water-Gas Drive process has also been ultimately evaluated by comparison with steamflood reference experiments.

The experimental program was statistically designed to enable quantitative assessment of the data. An oil recovery enhancement index has been defined, and consistently used in the statistical analysis of the experimental results.

Of the operating variables, and in the ranges examined, only injection temperature increase had the expected effect of increasing oil recovery (by the hot water-gas process). Fluid injection rates and back pressure had, statistically, insignificant effects on the process. Analysis of the results shows a significant advantage to using carbon dioxide, over nitrogen, in the hot water/gas drive process. Using interfacial additives, particularly NaOH, proved to have potential merit in connection with the process.

The results of this investigation suggest that heavy oil recovery by a combination of hot water and gas displacement is comparable to recovery using a steam drive (60-75% of original oil saturation, under the present set of experimental conditions). The study points to the controlling factors, range of sensitivities, and areas of potential improvements of the hot water/gas drive.

To highlight the significant findings of the study, an overall summary table is presented below.

## SOMMAIRE

Une étude de laboratoire sur le déplacement de l'huile lourde par la combinaison de l'eau chaude et du gaz a eu lieu. Cette étude était basée sur des expériences de déplacement du centre et à mesure de laboratoire, et n'a pas été augmentée. Deux huiles lourdes, une de l'Alberta (Pelican Lake) et l'autre de Saskatchewan (Buffalo Coulee), ont été utilisées. L'effet d'un assortiment de variable de fonctionnement (température d'injection, vitesse d'injection d'eau, vitesse d'injection de gaz et pression arrière) a été examiné. Les rôles potentiels d'un gaz soluble ( $\text{CO}_2$ ) et ceux des additifs interfaciaux (l'hydroxide de sodium et un additif de sulfonate de pétrole TRS 410) ont été évalués. Le processus "hot water-gas drive" a été aussi évalué par comparaison avec des expériences de référence d'inondation de vapeur.

Le programme expérimental a été construit statistiquement pour pouvoir quantitativement évaluer les résultats. Un index de rehaussement du recouvrement d'huile a été défini et a été utilisé durant l'analyse statistique des résultats expérimentaux.

D'entre les variables de fonctionnement, et dans l'assortiment étudié, seulement l'augmentation de la température d'injection a eu l'effet attendu d'augmenter le recouvrement de l'huile (par le chaud processus d'eau-gaz). Les vitesses d'injection de fluide, et la pression arrière ont, statistiquement, des effets insignifiants sur le processus. L'analyse des résultats montre un grand avantage d'utiliser le gaz carbonique à comparer avec le nitrogen durant le processus chaud d'eau/gaz. Utilisation des additifs, particulièrement NaOH, a prouvé un mérite potentiel à connection avec le processus.

Les résultats de cette recherche suggèrent que le recouvrement de l'huile lourde par la combinaison de l'eau chaude et du gaz de déplacement est comparable au recouvrement qui utilise la vapeur (60-75% de la saturation de l'huile originale, sous les mêmes conditions expérimentales). Cette étude marque les facteurs contrôllants de l'assortiment des sensitivités, et les parties d'amélioration potentielles dans le processus de l'eau chaude/gaz.

Pour mettre en vedette les découvertes de cette recherche, une table de sommaire est présentée ci-dessus.

SUMMARY TABLE

| RUN # | TABLE # | TEMP C | W RATE ML/H | G RATE L/H | PRESS PSIG | OIL      | GAS   | ADDOVE | SAND MESH | SALT CONC G/L | O.R.E.I. RECOVERY % |
|-------|---------|--------|-------------|------------|------------|----------|-------|--------|-----------|---------------|---------------------|
| C1    | A1      | 20     | 196         | ---        | 175        | PLCN     | ---   | ---    | 55        | 5             | N/A 35.9            |
| C2    | A2      | 50     | 247         | ---        | 175        | PLCN     | ---   | ---    | 55        | 5             | N/A 40.1            |
| C3    | A3      | 120    | 247         | ---        | 175        | PLCN     | ---   | ---    | 55        | 5             | N/A 52.7            |
| 3-01  | A4      | 175    | 530         | ---        | 200        | PLCN     | STEAM | ---    | 55        | 1             | N/A 76.6            |
| 3-02  | A5      | 175    | 530         | ---        | 220        | B. COLEE | STEAM | ---    | 55        | 1             | N/A 67.6            |
| 3-03  | A6      | 122    | 530         | ---        | 150        | PLCN     | STEAM | ---    | 55        | 1             | N/A 62              |
| 3-04  | A7      | 121    | 530         | ---        | 150        | B. COLEE | STEAM | ---    | 55        | 1             | N/A 63.8            |
| 4-01  | A8      | 100    | 500         | 36         | 200        | PLCN     | N2    | ---    | 55        | 5             | 4.4 57.7            |
| 4-02  | A9      | 124    | 1530        | 36         | 200        | PLCN     | N2    | ---    | 55        | 5             | 5.8 73.1            |
| 4-03  | A10     | 125    | 530         | 177        | 200        | PLCN     | N2    | ---    | 55        | 5             | 4.1 62.7            |
| 4-04  | A11     | 125    | 1530        | 177        | 200        | PLCN     | N2    | ---    | 55        | 5             | 7.3 62.5            |
| 4-05  | A12     | 106    | 530         | 36         | 100        | PLCN     | N2    | ---    | 55        | 5             | 4.1 62.8            |
| 4-06  | A13     | 105    | 1530        | 36         | 100        | PLCN     | N2    | ---    | 55        | 5             | 4.2 59.9            |
| 4-07  | A14     | 109    | 530         | 177        | 100        | PLCN     | N2    | ---    | 55        | 5             | 5.8 65.6            |
| 4-08  | A15     | 112    | 1530        | 177        | 100        | PLCN     | N2    | ---    | 55        | 5             | 4.6 67.8            |
| 4-09  | A16     | 154    | 530         | 32         | 200        | PLCN     | N2    | ---    | 55        | 5             | 10 57.9             |
| 4-10  | A17     | 154    | 1530        | 36         | 200        | PLCN     | N2    | ---    | 55        | 5             | 7.3 61.6            |
| 4-11  | A18     | 134    | 530         | 177        | 200        | PLCN     | N2    | ---    | 55        | 5             | 9.7 58.4            |
| 4-12  | A19     | 157    | 1530        | 177        | 200        | PLCN     | N2    | ---    | 55        | 5             | 7.3 69.7            |
| 4-13  | A20     | 154    | 530         | 36         | 100        | PLCN     | N2    | ---    | 55        | 5             | 7.5 64.8            |
| 4-14  | A21     | 154    | 1530        | 36         | 100        | PLCN     | N2    | ---    | 55        | 5             | 6.9 61.5            |
| 4-15  | A22     | 154    | 530         | 177        | 100        | PLCN     | N2    | ---    | 55        | 5             | 6.8 68.9            |
| 4-16  | A23     | 150    | 1530        | 177        | 100        | PLCN     | N2    | ---    | 55        | 5             | 7.7 67.9            |
| 5-01  | A24     | 106    | 530         | 36         | 100        | PLCN     | N2    | ---    | 55        | 5             | 4.1 62.8            |
| 5-02  | A25     | 103    | 530         | 36         | 100        | PLCN     | CO2   | ---    | 55        | 5             | 13.6 63.3           |
| 5-03  | A26     | 102    | 530         | 36         | 100        | PLCN     | CO2   | ---    | 125       | 5             | 13.6 56.5           |
| 5-04  | A27     | 102    | 530         | 36         | 100        | PLCN     | CO2   | ---    | 125       | 5             | 5.4 69.2            |
| 5-05  | A28     | 102    | 530         | 36         | 100        | B. COLEE | N2    | ---    | 55        | 5             | 7.1 61.2            |
| 5-06  | A29     | 102    | 530         | 36         | 100        | B. COLEE | N2    | ---    | 55        | 5             | 15.1 60.1           |
| 5-07  | A30     | 102    | 530         | 36         | 100        | B. COLEE | CO2   | ---    | 125       | 5             | 10.9 66.1           |
| 5-08  | A31     | 102    | 530         | 36         | 100        | B. COLEE | N2    | ---    | 125       | 5             | 9.2 65.6            |

cont.

SUMMARY TABLE

| RUN<br># | TABLE<br># | TEMP<br>C | W RATE<br>ML/H | G RATE<br>L/H | PRESS<br>PSIG | OIL     | GAS | ADDVE  | SAND<br>MESH | SALT CONC<br>G/L | O.R.E.I. | RECOVERY<br>% |
|----------|------------|-----------|----------------|---------------|---------------|---------|-----|--------|--------------|------------------|----------|---------------|
| 6-01     | A32        | 102       | 530            | 36            | 100           | PLCN    | N2  | NaOH/L | 55           | 1                | 6.6      | 76.3          |
| 6-02     | A33        | 102       | 530            | 36            | 100           | PLCN    | N2  | NaOH/H | 55           | 1                | 5.7      | 75.4          |
| 6-03     | A34        | 101       | 530            | 36            | 100           | PLCN    | N2  | TRS/L  | 55           | 1                | 3.9      | 68.6          |
| 6-04     | A35        | 100       | 530            | 36            | 100           | PLCN    | N2  | TRS/H  | 55           | 1                | 2        | 64.1          |
| 6-05     | A36        | 102       | 530            | 36            | 100           | B.COLEE | N2  | NaOH/L | 55           | 1                | 4.5      | 62            |
| 6-06     | A37        | 101       | 530            | 36            | 100           | B.COLEE | N2  | NaOH/H | 55           | 1                | 4.2      | 64            |
| 6-07     | A38        | 100       | 530            | 36            | 100           | B.COLEE | N2  | TRS/L  | 55           | 1                | 4        | 66.4          |
| 6-08     | A39        | 102       | 530            | 36            | 100           | B.COLEE | N2  | TRS/H  | 55           | 1                | 3        | 65.7          |
| 6-09     | A40        | 102       | 530            | 36            | 100           | PLCN    | N2  | NaOH/L | 55           | 5                | 2.9      | 61.2          |
| 6-10     | A41        | 102       | 530            | 36            | 100           | PLCN    | N2  | TRS/L  | 55           | 5                | 2.1      | 65.5          |
| 6-11     | A42        | 103       | 530            | 36            | 100           | B.COLEE | N2  | NaOH/L | 55           | 5                | 2.8      | 65            |
| 6-12     | A43        | 105       | 530            | 36            | 100           | B.COLEE | N2  | TRS/L  | 55           | 5                | 2.8      | 59.9          |
| 6-13     | A44        | 100       | 530            | 36            | 100           | B.COLEE | N2  | TRS/H  | 55           | 5                | 2.8      | 60.17         |
| 6-14     | A45        | 101       | 530            | 36            | 100           | B.COLEE | N2  | NaOH/H | 55           | 5                | 5.8      | 73.3          |
| 6-15     | A46        | 105       | 530            | 36            | 100           | PLCN    | N2  | NaOH/H | 55           | 5                | 2.6      | 58            |
| 6-16     | A47        | 102       | 530            | 36            | 100           | PLCN    | N2  | TRS/H  | 55           | 5                | 2.4      | 59.9          |

NOTES:

1. Table # above refers to complete tables in Appendix A.
2. TEMP, W. RATE, G. RATE, PRESS above are nominal values of injection temperature, water injection rate, gas rate, and outlet back pressure.
3. PLCN and B.COLEE refer to Alberta Pelican Lake oil and Saskatchewan Buffalo Coulee oils respectively.
4. ADDVE: NaOH/L and NaOH/H refer to the Sodium hydroxide at its low (1 g/l) and high concentration (5 g/l) respectively. TRS/L and TRS/H refer to the petroleum sulfonate additive TRS-410 at its low (1 g/l) and high concentration (3 g/l) respectively.
5. SALT CONC refers to salt concentration in the connate water.
6. O.R.E.I. is an Oil Recovery Enhancement Index calculated as the ratio of oil recovery rate just before and after switching from water to gas injection. For the series of experiments 6-01 to 6-16, it is the ratio just before and after switching from additive to gas injection. Direct comparison, therefore, between the set of experiments 6-xx and the two sets 4-xx and 5-xx is not possible.
7. RECOVERY %: is the observed ultimate oil recovery, after which only small amounts of oil were produced at such reduced rates. The Oil Recovery Enhancement Index reflects more sensitivity to the experimental conditions (see sections on the statistical analysis of data).

## CONCLUSIONS AND RECOMMENDATIONS

The process of hot water followed by gas injection has been tested on two heavy oils from Alberta and Saskatchewan. The following main conclusions and recommendations have been reached on the basis of a bench scale statistically designed experimental program:-

- Oil recoveries using the hot water/gas drive process were comparable to the recoveries obtained in steamflood reference experiments (60 - 75% of original oil saturation). This result supports the hypothesis, recently advanced in the literature, that injection of a small amount of gas following hot water injection can displace heavy oils as effectively as does the continuous injection of steam. The result further confirms that a steam drive may be conceptualized as consisting of two complementary parts: reservoir heating by fluid injection and significant oil displacement by high velocity gas.
- An oil recovery enhancement index (defined as the ratio of oil recovery rate after gas injection to that before gas injection) was found to be an effective parameter in characterizing and analyzing the oil displacement experiments.
- Of the operating variables examined (water injection temperature, water injection rate, gas injection rate, and back pressure), only the hot water injection temperature was found to have a statistically significant effect on oil recovery by the hot water/gas drive. As may be expected, a higher injection temperature resulted in a higher oil recovery.
- A change of sand core permeability had little effect on oil recovery by the hot water/gas displacement process.
- Injection of  $\text{CO}_2$  showed a statistically significant recovery improvement over  $\text{N}_2$  injection in connection with the hot water/gas drive. Therefore use of  $\text{CO}_2$ , or other oil soluble gases, is recommended for the hot water/gas displacement process.
- Interfacial additives showed beneficial oil recovery effects when applied in the hot water/gas process.
- Sodium hydroxide resulted in higher oil recoveries in comparison to the petroleum sulfonate additive TRS 410.
- Higher connate water salt concentration resulted in relatively unfavourable interactions with both sodium hydroxide and the sulfonate additive TRS 410.
- Based on the promising results of this investigation, scaled physical model experiments and pilot testing of the process are recommended. Detailed analysis of the economic advantages of the process is also called for.
- Water injection temperature, choice of gas and interfacial additives are key variables worthy of further investigation and optimization.

## PART I: BACKGROUND

### 1. LITERATURE REVIEW

The classical view of a steam drive (1) assumes that a steam zone develops across the entire cross section of a reservoir, and that the oil is recovered by virtue of frontal displacement. Such a view is known to be inaccurate, particularly for viscous crudes (2), since a bank of high viscosity oil cannot be displaced at a significant rate under the pressure gradients typically created. It is only under special reservoir conditions, such as a thick formation or with a significant reservoir dip inducing a process of gravity drainage (3), that a viscous crude could be recovered at an acceptable oil-steam ratio. In general, it is well known (4) that steam will override an oil zone, and will subsequently break through at the producing wells. The steam override effect is generally believed to be the main factor which limits the efficiency of a steam drive.

However, the negative view about the phenomenon of steam override is not totally correct. This view is now being challenged (5) on the following grounds:-

- . If it were not for the override of steam and the accompanying early breakthrough, the producing wells could not be kept hot enough to provide the necessary high mobility (low viscosity) for the viscous crudes to flow.
- . If it were not for the override, or channelling of steam through high mobility zones, the steam could not encounter oil to heat (increasing its mobility) and would be limited to heating a small zone at the displacement front.
- . The totally negative view about steam override is not consistent with the recent indications (6,7) that a steam drive is surprisingly efficient in reservoirs of high specific gravity crudes, but not in those containing very viscous crudes and bitumen (viscosity > 5000 cP at about 100°F).

The modified understanding (5) of the steamflood process suggests the following:-

- . The controlling factor in the efficiency of a steam drive is the degree of mobile oil saturation around the producing wells.
- . The damaging effect of steam channelling through a low oil saturation zone is that steam pressure within the depleted sand will block the drainage of oil into the steam zone. However, as long as a tongue of mobile oil can reach the producing well, oil production will be maintained.
- . The much higher reservoir velocities of a steamflood account for the much higher recovery rates, associated with a steam drive, over a hot water drive.

- The steam drive is, therefore, conceptualized as consisting of two complementary parts: heating the oil at the interface with the overriding steam, and dragging or stripping the oil by the high velocity steam.

According to this understanding of the process it should, therefore, be possible to use a combination of a hot waterflood and a gas drive (having an equivalent volumetric flow rate as that of steam vapour) to achieve the same efficiency as a steamflood. This process has the obvious advantage of eliminating the need for costly steam generation and associated water treating equipment. The reduced heat losses and relatively lower sensitivity of the process to reservoir heterogeneity give the process special attractiveness for many of the Canadian heavy oil reservoirs.

Only one study (5) of the process has appeared in the open literature. In that study nitrogen was used as the drive gas. We believe that an oil-soluble gas such as  $\text{CO}_2$  may offer additional benefits such as further reduction of oil viscosity, oil swelling, and solution gas drive (8,9). Naturally an optimization of the prevailing hot water temperature and gas solubility will be required to achieve the best injection conditions for a soluble gas. Furthermore, the referenced study (5) did not offer any statistical analysis of obtained results. For an accurate assessment of the process, it must be tested with Canadian crudes under a statistically designed program.

The benefits of interfacial additives such as surfactants have been demonstrated in recent laboratory tests and field pilots (10-14). The use of such additives can be made an integral part of the hot water/gas drive process. Some limited testing has been carried out in the original examination of the process (5). Much more testing with other additives is still called for.

Two previous CANMET studies (15,16) have examined the use and role of alkalies and other additives in the recovery of heavy oils. A number of areas in those two earlier studies are pertinent to the present research program. The two heavy oils used in the present project (Pelican Lake oil/Alberta, and Buffalo Coulee oil/Saskatchewan) have been the subject of extensive analytical characterization in the referenced investigations (15,16). The choice of additives for the current program (Sodium hydroxide and the petroleum sulfonate additive TRS 410) was made in light of the previous findings.

Many of the mechanisms which have been widely studied in connection with the use of additives, non-condensable gases and oil-soluble gases with steam are directly applicable to the process of hot water/gas injection. It is therefore important, to the understanding of the hot water/gas drive process, to review the role of some of these additives and controlling mechanisms. As will become clear from the following review, the use of some of the additives may be better suited, and more beneficial, in case of the hot water/gas injection project.

For example, for almost two decades, and until recently, methods of maximizing oil recovery by steam injection have concentrated on the problems of reservoir conformance and poor vertical sweep efficiency. Attempts, thus, have been made to use foaming agents to help in distributing the heat, of the injected steam, uniformly across the productive intervals of a reservoir (17,18).

The foam process was apparently first suggested, in connection with waterflooding, by Bond et al in 1958 (19). It has since been extensively investigated (20-28). It was not till the mid-1970's, however, when more attention was directed to studying the foaming agents in connection with steam injection processes, and to evaluating the effectiveness of foams at elevated temperatures (17,18,30-34).

It is believed (29) that possible beneficial effects of foaming additives are derived from three basic mechanisms. First, foam is relatively low-density material which can easily overcome gravitational effects. It can, therefore, act as a diverting agent which reduces the well known gravity override of steam. Secondly, as a blocking agent, foam can be applied to selectively reduce the permeability of high permeability zones in a heterogeneous reservoir. The third mechanism is based on using foam as a mobility control agent. In this mechanism the mobility of injected steam is reduced by the generation of in-situ foam, resulting in an improved displacement efficiency.

In a Midway-Sunset field demonstration (18), a year-long injection of foam with steam resulted in an estimated 30,000 bbl and 50,000 bbl improvement in oil recovery, from the pattern wells and wells outside the pattern respectively. Diversion of steam was believed to have been achieved by three-phase flow and some foam type of activity. It was also suggested that a viscosity increase, in the flowing-steam phase, resulted in enhancing the volumetric conformance. The dominant effect, however, was attributed to a chemical-additive-augmented steam drive in which oil recovery is enhanced by improved emulsification, lowered interfacial tension, and entrainment of the oil in the flowing steam and hot water phase.

Presently, the effect of foam plugging in enhancing oil production appears to be highly controversial (5). It is argued that laboratory results which predict the performance of foam with steam, e.g. (35), are irrelevant to reservoir conditions. Some field results which show significant increase in oil production (35) are also discounted (5), on the grounds of being a continuation of a trend that was initiated months before the injection of steam foam. Furthermore, doubt has also been cast (5) on the in-situ formation of foams in the presence of steam. This is based on the fact that the foam process requires the presence of a very high liquid volume fraction ( $5 \times 10^{-2}$ ) to cause maximum pressure increase. At 5% quality 200 pound steam has a liquid volume fraction of only  $5 \times 10^{-4}$ , which would not be sufficient to form effective foam.

A very recent study (36), nevertheless, suggests that foams appear to reduce steam mobility, to improve injection profiles, and to raise reservoir temperature at least near injection wells. The study concedes that data to establish that foams can do the same far into the reservoir are not available. However, the referenced investigation concludes that when a non-condensable gas is incorporated, steam foams recover additional oil over a straight steam drive, increase the oil fractional flow at production wells, and improve oil/steam ratios. These beneficial effects are attributed to lengthening of bubble lifetimes in the presence of non-condensable gas.

It is clear from the above review/discussion that foam agents\*are better suited to the hot water/gas drive, due to the presence of high liquid fraction and non-condensable gas.

Another recovery enhancement technique is based on the use of volatiles such as solvents (37,38), gases (39-41), and mixtures of gases and solvents in combination with steam. The use of these additives is supposed to further such beneficial mechanisms as creating initial conductivity to steam, lowering the viscosity of oil, promoting oil swelling, solution gas drive and gas expansion drive.

The majority of laboratory tests and numerical simulation studies indicated a good potential for these additives (42). Generally an acceleration of oil recovery and small increase in total produced oil have been predicted (41,43,44). With the very limited testing to-date, the viability of these processes has yet to be established, particularly in view of the present economic environment. Nevertheless, the use of soluble gases and volatiles appears to be more suited to the hot water/gas drive, than to steam drive, due to lower prevailing temperatures resulting in better solubility conditions.

The mechanisms of enhancing oil recovery by using alkaline additives are also pertinent to this study. It is well established that injection of alkaline solutions, into an oil reservoir, leads to in-situ generation of surfactants. The generation of surfactants is due to chemical reactions between the alkaline substance and the organic acids present in the crude oil. The presence of surfactants, in turn, results in a number of beneficial mechanisms; such as emulsification, interfacial tension reduction, and favourable wettability changes. An extensive study (16) to assess the alkaline waterflooding process for heavy oils has recently been completed. A detailed review of the process, evaluation of the mechanisms involved, and assessment of its potential may be found in that study.

While alkaline additives have shown promising results in low temperature waterflooding conditions (16,45,46), they had little success when applied with steam in laboratory (47) or field tests (48). Their lack of success appears to be mainly due to excessive reaction with the reservoir rock matrix at steam temperatures. Detailed analysis of mineral/alkali reactions may be found in a recent study by Mohnot et al (49).

It is clear from the above, that the use of alkaline additives is more suited to the hot water/gas process than to steam injection, due to the lower temperatures involved in the former.

With the controversy surrounding the application of foaming agents and alkaline solutions, increasingly more attention is being directed to the use of other interfacially active agents. There is a vast number of chemicals which have been suggested, and belong to this category.

The main function of this category of interfacially active additives is to enhance the displacement efficiency from the hot water zone. One or more of a variety of mechanisms is supposed to play a role in the efficiency improvement. These mechanisms include oil-water interfacial tension reduction, water-in-oil emulsion destabilization, emulsification and entrainment of oil, favourable wettability changes, and reduction of the viscosity of the oil-water interfacial layer.

Among the interfacial additives of current interest to heavy oil recovery (50-53) are petroleum sulfonates, alpha olefin sulfonates, and synthetic alkylaryl sulfonates. Petroleum sulfonates (which also show some foaming characteristics) have been shown, in laboratory displacement tests, to substantially improve oil recovery and reduce residual bitumen saturations (52). Some concern over the thermal degradation of petroleum sulfonates and their loss during laboratory displacements was expressed in that study. Another study (53) predicted the improvement in steamflood oil recovery, due to the application of sulfonate additives, to reach about 8 to 32% for a Kern River-type reservoir. In the latter study, it was also demonstrated that the alpha olefin and synthetic alkylaryl sulfonates exhibit sufficient thermal stability to enable their use as steam additives. Comparative evaluation of a number of steam additives (53) gave further evidence of the superiority of sulfonate additives for bitumen recovery.

## PART II: STUDY PROGRAM

### 2. FLUIDS CHARACTERIZATION

Two heavy oils from Alberta and Saskatchewan reservoirs have been used in this study.

The Saskatchewan oil was supplied by the Petroleum Division of Saskatchewan Research Council (Dr. R. Ranganathan), from the Buffalo Coulee area. The Alberta heavy oil was obtained through Gulf Canada, from the Pelican Lake steam injection pilot. The two oils have been selected mainly due to the difference in the viscosities; oil viscosity effect is one of the parameters to be investigated in this project. Table 2.1 shows the properties, pertinent to the investigation, measured for each of the two oils.

The selected oils have been the subject of extensive characterization under previous CANMET projects (15,16); No. O.S.Q.84-00094 and O.S.Q.85-00072. The properties and compositional analysis of formation waters from a number of Alberta and Saskatchewan areas have also been reported in the above referenced CANMET projects. No fresh formation water samples were obtained with either of the two new oil samples. Typical formation water analysis for an Alberta and a Saskatchewan oil field is given in Table 2.2 and Table 2.3, respectively (15).

Two interfacial additives have been selected for investigation in this project. These additives are:-

1. Petroleum Sulfonate additive TRS 410 (Surpass Chemicals - Subsidiary of WITCO)
2. Sodium Hydroxide

In the previous studies (15,16), each of the selected additives showed favourable interfacial tension reduction characteristics, and enhancement of oil recovery. The petroleum sulfonate additives are also known to have possible beneficial foaming effects. Foaming is believed to be more pronounced in the case of the hot water process, than in connection with steam injection. In-situ formation of foam is known to require very high liquid volume fraction, a condition which is nearly impossible to achieve in steam applications. While the reason is different, sodium hydroxide is also believed to be more suited to the hot water process than as a steam additive. In the latter case, the high steam injection temperatures can result in excessive reaction between the alkali and reservoir rock.

Qualitative compatibility testing of the two additive solutions with brine has been conducted. The aim of these qualitative tests was to identify potential interaction problems; as may be detected by the formation of precipitates.

In these tests, each of the additive solutions was mixed with an equal volume of brine solution (1 g/L and 5 g/L). No precipitation was observed with any of the additive solutions.

TABLE 2.1

BASIC PROPERTIES OF HEAVY OILS

|                                       | Pelican Lake<br>Oil<br>Alberta | Buffalo Coulee<br>Oil<br>Saskatchewan |
|---------------------------------------|--------------------------------|---------------------------------------|
| Viscosity (cSt)                       |                                |                                       |
| 25°C                                  | 773.86 (745.64 mPa.S)          | 1575.86 (1519.25 mPa.s)               |
| 40°C                                  | 320.05                         | 544.76                                |
| Density (g/cm <sup>3</sup> )          |                                |                                       |
| 15°C                                  | 0.9710                         | 0.9715                                |
| 60°C                                  | 0.9374                         | 0.9381                                |
| Water Content (wt%)<br>(Dean & Stark) | 3.4                            | 0.1                                   |

TABLE 2.2

PELICAN LAKE FORMATION WATER ANALYSIS\*

| <u>ION</u>  | <u>g/M<sup>3</sup></u> |
|-------------|------------------------|
| Sodium      | 1950                   |
| Potassium   | 123                    |
| Calcium     | 3.0                    |
| Magnesium   | 5.8                    |
| Iron        | <0.2                   |
| Chloride    | 1520                   |
| Sulphate    | 22.7                   |
| Carbonate   | 123                    |
| Bicarbonate | 2463                   |

\* Ref.(15)

TABLE 2.3

TYPICAL W EDAM FORMATION WATER ANALYSIS\*

| <u>ION</u>  | <u>g/M<sup>3</sup></u> |
|-------------|------------------------|
| Sodium      | 20,599                 |
| Potassium   | 427                    |
| Calcium     | 680                    |
| Magnesium   | 730                    |
| Iron        | 0.7                    |
| Chloride    | 37,800                 |
| Sulphate    | 28                     |
| Carbonate   | --                     |
| Bicarbonate | 673                    |

\*Ref. (15)

### 3. EQUIPMENT SET-UP AND COMMISSIONING RUNS

#### 3.1 Equipment Set-Up

A sand-packed core holder equipped with hot water injection, gas injection and steam injection apparatus has been used for the displacement experiments of this project. The sand core holder consisted of an insulated stainless steel cylinder (4.75 cm I.D. x 61 cm long). The core holder was fitted with teflon spacer blocks, diffusers, and fine mesh screens for retaining the sand pack, Figure 3.1. As shown in Figure 3.1, the fluid injection equipment consisted of the following main components:-

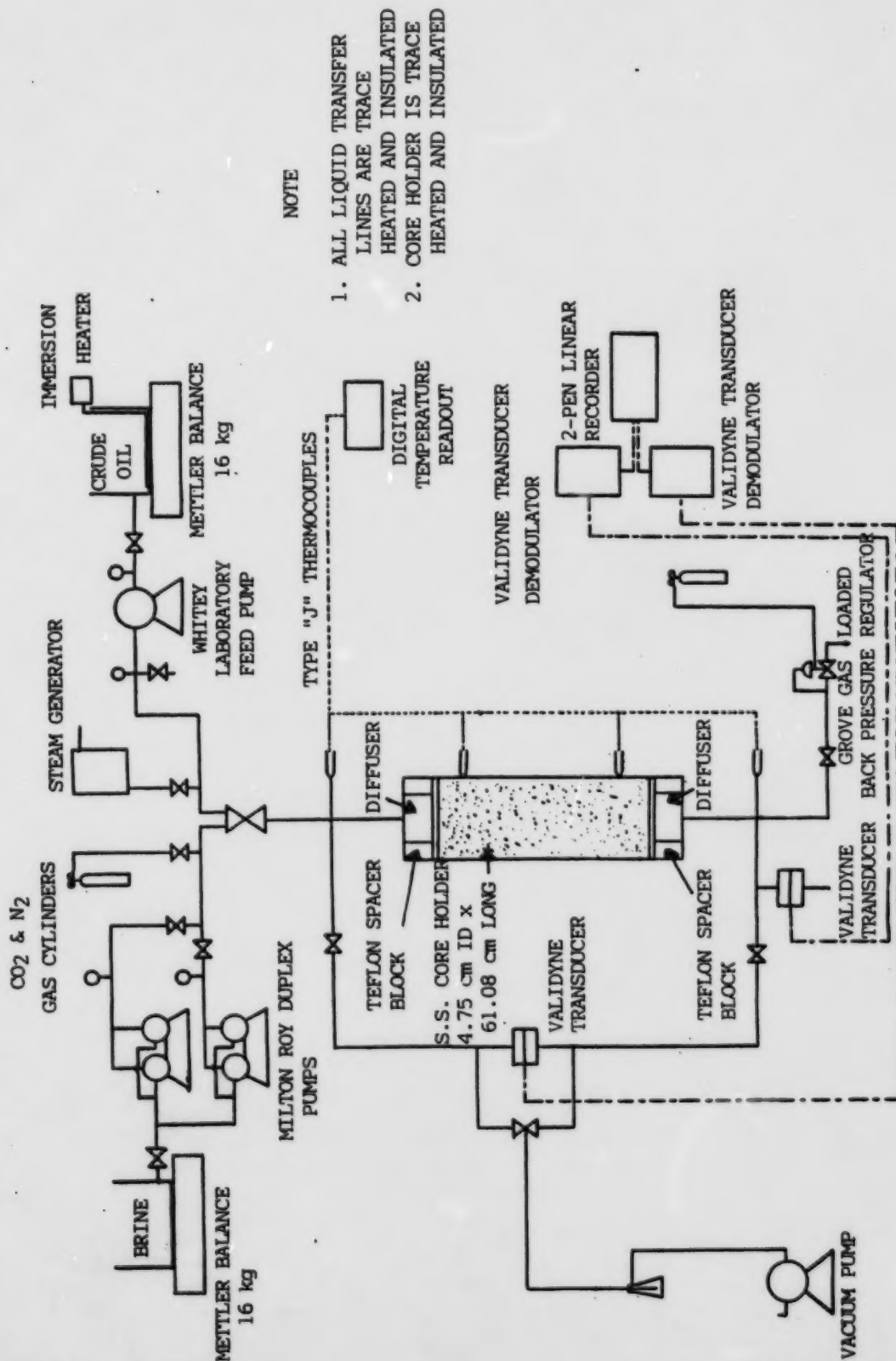
- vacuum pump for core preparation
- brine injection set-up, consisting of a feed vessel and two Milton Roy Duplex pumps
- crude oil feeding system, for the initial saturation of the sand core. This system included a crude oil feed vessel fitted with an immersion heater, and a Whitey Laboratory Feed Pump
- steam generation equipment
- gas injection cylinders
- monitoring, control and measurement instruments. These included Mettler balances for monitoring liquid injection, pressure gauges for monitoring gas injection, and pressure regulators for the control of fluid injection-production. Thermocouples, Validyne pressure transducers, pressure transducer modulators, digital readouts and records have been also prepared for observing the displacement process
- all the liquid transfer lines are insulated and fitted with trace heating elements

Two different mesh size Ottawa sands have been obtained (Canadian Foundry Suppliers Ltd., Toronto, Ontario). The first has a nominal 55 mesh size, while the second is 125 mesh silica sand. These two sands have been used for core preparation throughout this research program.

A number of measurements and basic determinations have been carried out, as a part of equipment testing and preparation. These included:-

- Preliminary sand packing procedure. The weight of 55 mesh sand required to fill the core holder was determined to be 1760 g. The packing procedure was repeated and standardized; and a constant weight sand pack (of about 1760 g) was used throughout the study.
- The sodium chloride concentration in the brine solution has been selected as 5 g/L. This concentration was also kept constant from run to run. The salt concentration, of 5 g/L, has been selected to match the levels typically encountered in the Pelican Lake (Alberta) area, e.g. Table 2.2. Saskatchewan formation waters are known to have significantly higher salt concentrations, e.g. Table 2.3.

FIGURE 3.1  
OIL DISPLACEMENT SET-UP



- The pore volume of the sand core has been measured (by brine saturation of the core, and noting the weight difference between the feed and produced brine) to be 433 mL. This amounts to a porosity of 0.4, for the high permeability 55 mesh sand.
- A number of pressure drop-flow rate measurements have been carried out to ensure the sensitivity of the pressure transducers.
- Analytical methods (IR) for measuring the water-oil ratio, of the displaced fluids, were also tested and standardized.

### 3.2 Preliminary Commissioning Runs

Three oil displacement commissioning runs have been carried out at three different temperatures. In each of the three test runs, Pelican Lake oil was used. In the first run brine solution (5 g/L) was used as the displacing fluid and was injected at room temperature (20°C). In the second, brine was injected at 50°C. In each case, a back-pressure of approximately 200 psig was maintained at the outlet of the core holder. In the third displacement experiment, steam at 120°C was used as the injection fluid. No back-pressure was applied in the latter case due to limitations of the laboratory steam generator used.

Each of the three displacement experiments followed the general procedure outlined below:-

- The core holder was packed, in each case, with approximately 1760 g of homogenized 55 mesh Ottawa sand.
- The sand core was saturated with water at room temperature.
- Several pore volumes of oil were subsequently used to displace the water from the core. Oil injection continued until the water saturation was reduced to approximately 10%.
- The oil was then displaced with the injection fluid at a nearly constant rate (200-250 mL/h).
- In the case of the preliminary steam run (Run 3), some experimental problems were faced such that the flow rate was neither closely controlled nor monitored.
- The produced fluid was collected at pre-selected intervals and analyzed for water/oil ratio.
- The run was terminated after injection of about 5 pore volumes of fluid.

The results of the commissioning runs are displayed in Figures 3.2 to 3.9. The figures show the cumulative oil recovery and cumulative water/oil ratio for each experiment. The inlet and outlet pressure histories for the first two experiments are also displayed. No pressure profile is shown for Run 3, for no back-pressure was applied in the latter case, as mentioned earlier. The following main features may be observed from the figures:-

- . The oil recovery and cumulative water/oil ratio profiles follow the general trends normally observed in similar laboratory set-ups.
- . As expected, increase of oil recovery and decrease of water/oil ratio is observed with increased injection fluid temperature. Thus, oil recovery (at 3 PV of fluid injection) for Run 1 is about 33%, for Run 2 is approximately 38%, and about 50% for Run 3. The water/oil ratios on the other hand decrease by a similar relative magnitude in the three cases respectively.
- . The inlet pressure shows an expected large drop, coinciding with the injection fluid breakthrough. After breakthrough, the pressure drop across the sand pack remains relatively constant.

FIGURE 3.2

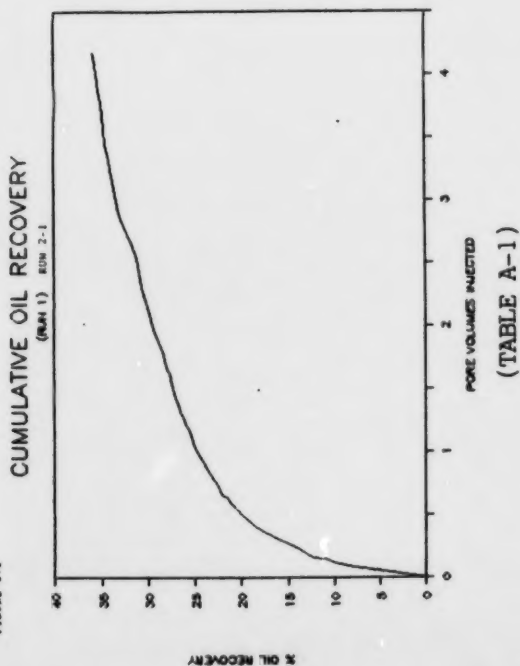


FIGURE 3.4

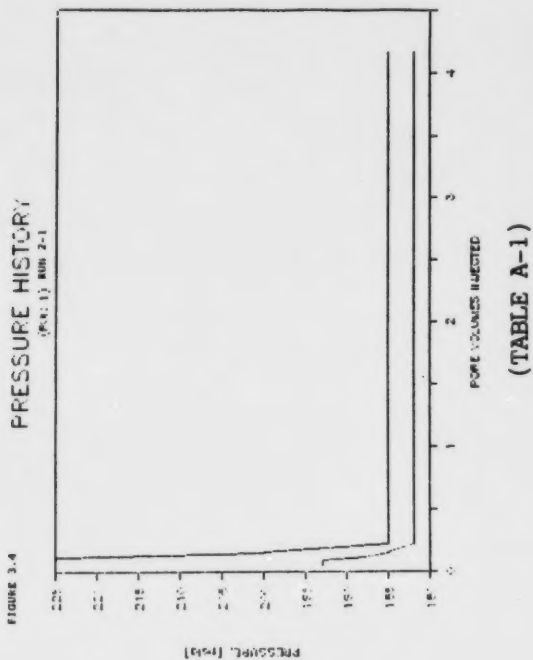


FIGURE 3.3

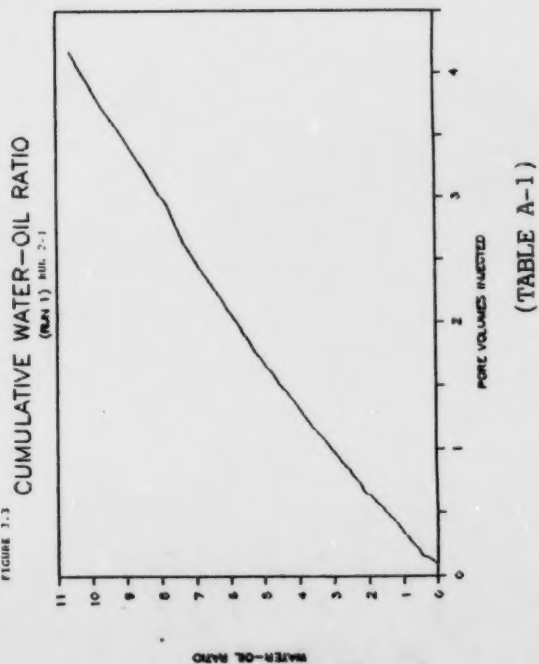


FIGURE 3.5

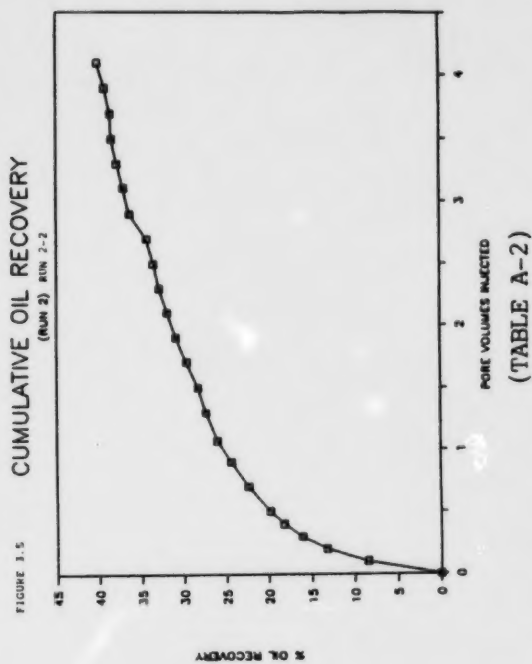
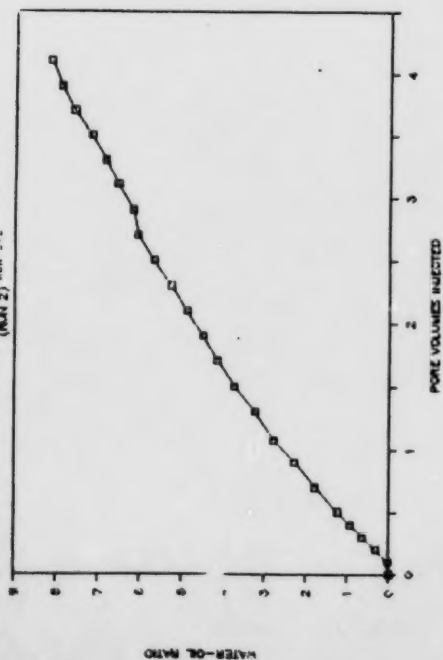


FIGURE 3.6

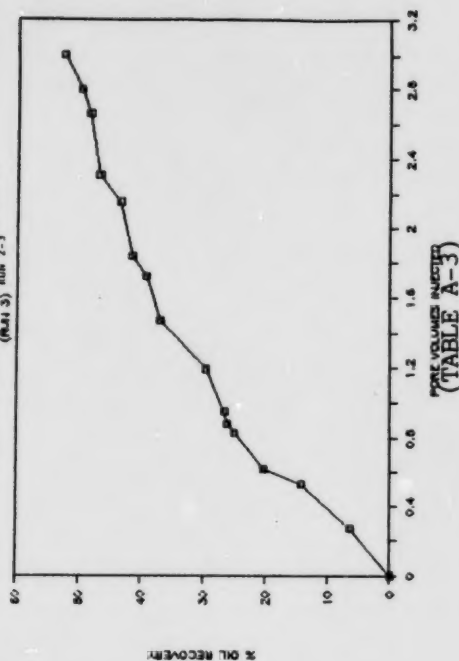
CUMULATIVE WATER-OIL RATIO  
(RUN 2) RUN 2-2



(TABLE A-2)

FIGURE 3.6

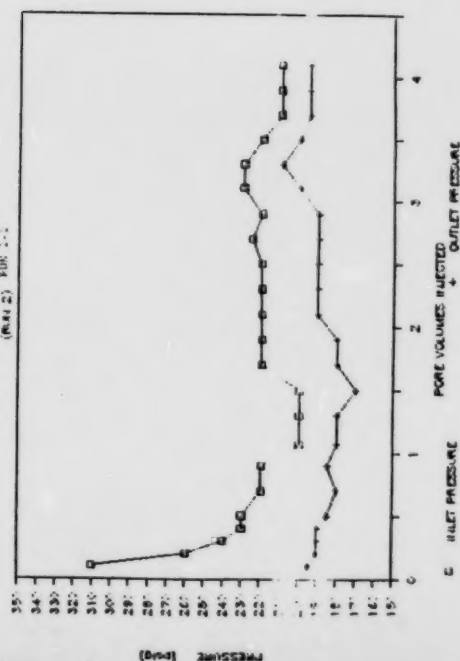
CUMULATIVE OIL RECOVERY  
(RUN 3) RUN 2-3



(TABLE A-3)

FIGURE 3.7

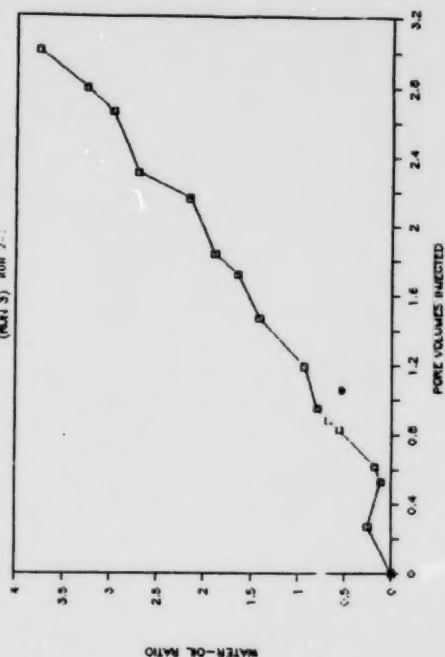
PRESSURE HISTORY  
(RUN 2) RUN 2-2



(TABLE A-2)

FIGURE 3.9

CUMULATIVE WATER-OIL RATIO  
(RUN 3) RUN 2-3



(TABLE A-3)

#### 4. STEAM REFERENCE RUNS

Four steam flooding experiments were carried out, at two different injection temperatures (175, 120°C) using the two different heavy oils (Pelican Lake and Buffalo Coulee). The conditions of the four experiments are listed in Table 4.1. The laboratory steam injection system consisted basically of a pumping unit and a water coil heated to the desired target temperature while allowing injection under controlled pressure. The steam in all four experiments was injected at constant rate under slightly superheated conditions. The injection was identical in all four runs (530 mL/hour at standard conditions).

The standardized core packing, saturation and injection procedures, previously adopted for the hot water/gas drive experiments, were also applied in this last set of runs.

Figures 4.1 to 4.16 summarize the results of oil recovery and cumulative water-oil ratios as well as the associated temperature and pressure profiles.

It is clear from the results that Runs 3-01 and 3-02 show significantly higher oil recoveries than Runs 3-03 and 3-04. The oil recovery (at about 5 PV injection) in the first two ranges from 70 to 75%, while the oil recovery of the latter two runs amounts to between 60 and 65%. This reflects the expected effect of temperature (175°C in the first two, and 120°C in the last two). Comparison of the results also shows higher recoveries associated with the Pelican Lake oil. At each of the two operating temperatures, the recovery of Buffalo Coulee oil is about 5% less than corresponding Pelican Lake oil recovery. This is a direct result of the difference in viscosity between the two oils. Observations consistent with the above may be also directly derived from the water-oil ratio results.

As will be seen in the next several sections of the report, there are general similarities between the temperature and pressure profiles of the steam reference runs and the hot water/gas experiments (Sections 5 to 7). Distinct differences in the oil recovery and water-oil ratio curves will become apparent. In the steam runs set of experiments, a steady increase of oil recovery, accompanying the increase of core temperature, is apparent. In the following sections, a characteristic part of the oil recovery and water-oil ratio profiles, associated with gas injection is consistently apparent.

TABLE 4.1  
STEAM REFERENCE RUNS

| <u>Experiment</u> | <u>Oil</u>         | <u>Injection Temp.<br/>(Nominal °C)</u> |
|-------------------|--------------------|-----------------------------------------|
| 3-01              | Pelican Lake Oil   | 175                                     |
| 3-02              | Buffalo Coulee Oil | 175                                     |
| 3-03              | Pelican Lake Oil   | 120                                     |
| 3-04              | Buffalo Coulee Oil | 120                                     |

|                                  |                   |
|----------------------------------|-------------------|
| Injection Rate                   | 530 mL/h (at stp) |
| Back Pressure                    | 100 psig          |
| Connate Water Salt Concentration | 1.0 g/L           |

FIGURE 4.1

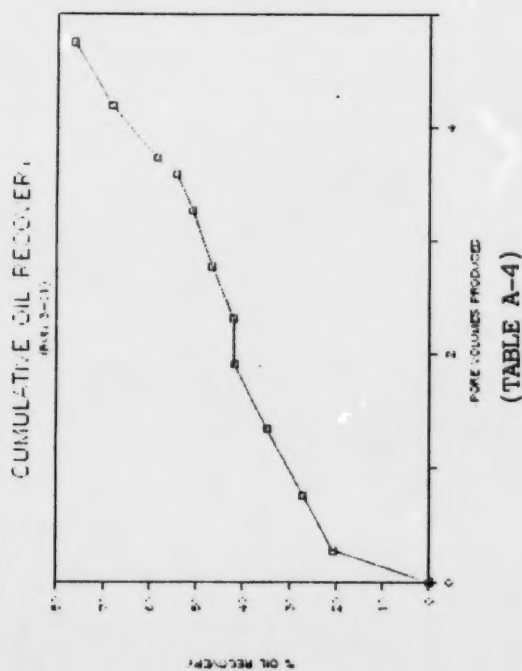


FIGURE 4.3

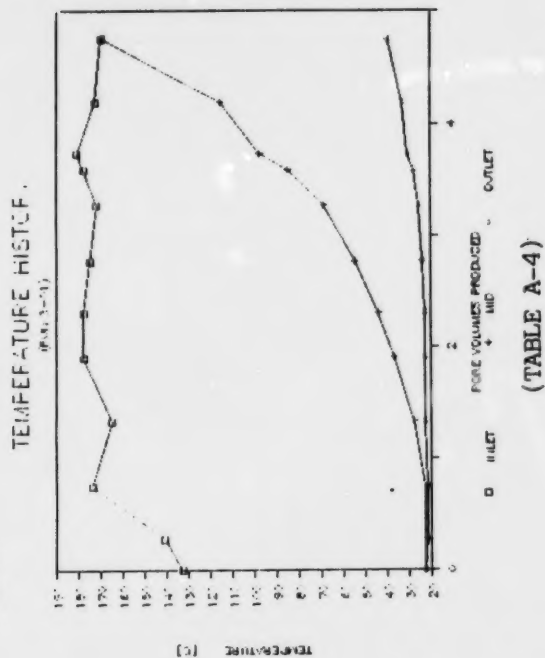


FIGURE 4.2

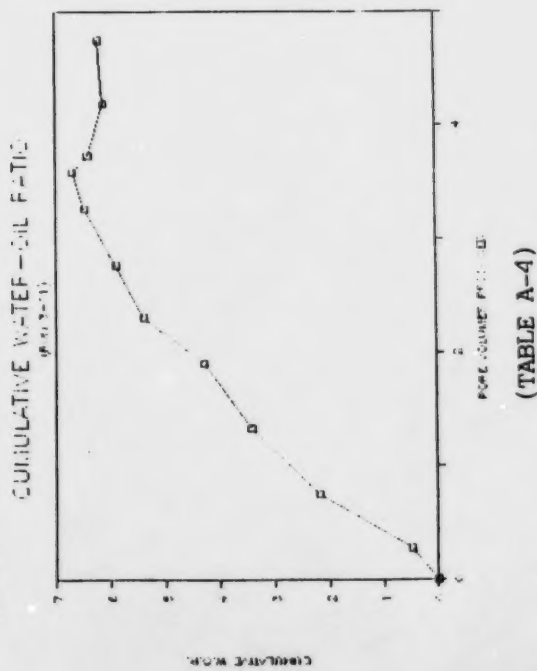


FIGURE 4.4

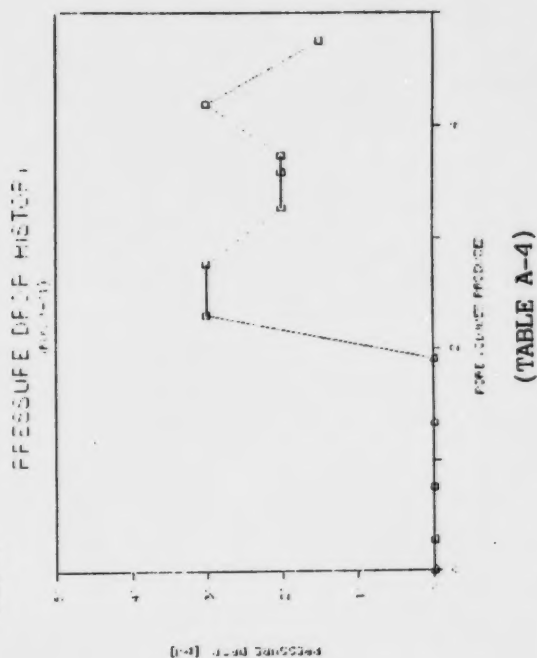


FIGURE 4.5

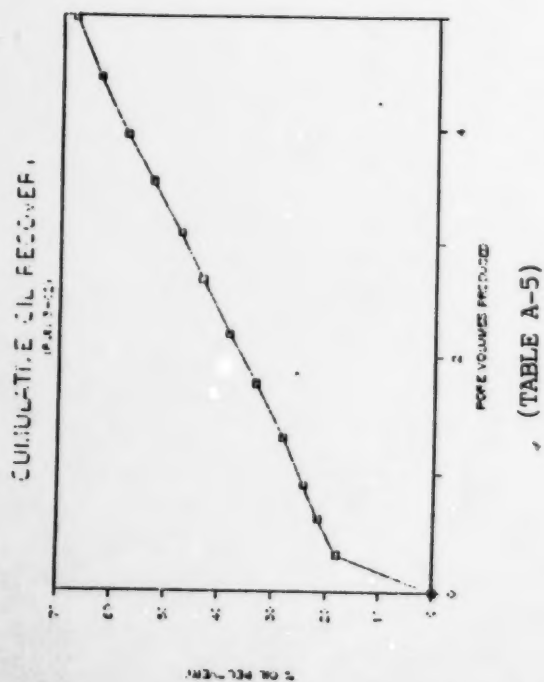


FIGURE 4.7

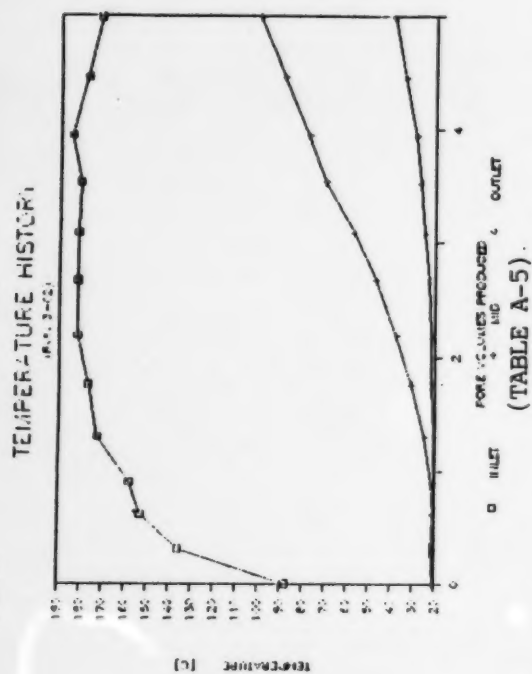


FIGURE 4.6

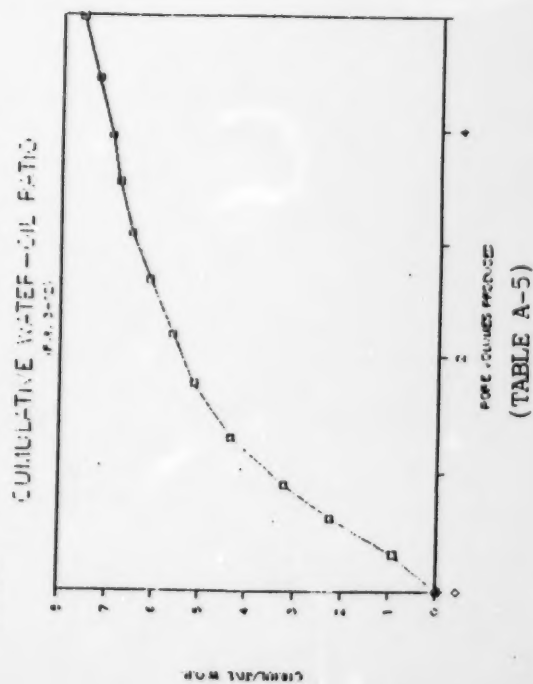


FIGURE 4.8

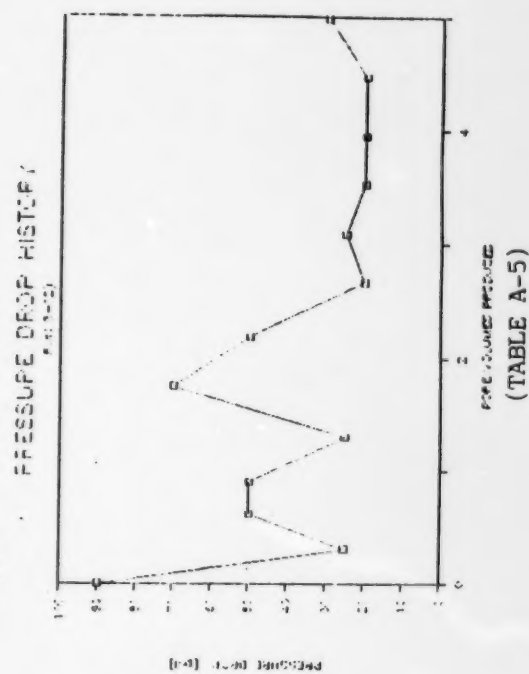


FIGURE 4.9

CUMULATIVE OIL RECOVERY

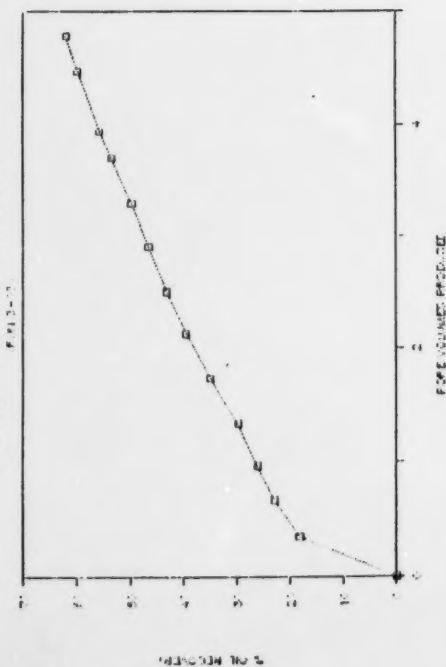


FIGURE 4.10

CUMULATIVE WATER-OIL RATIO

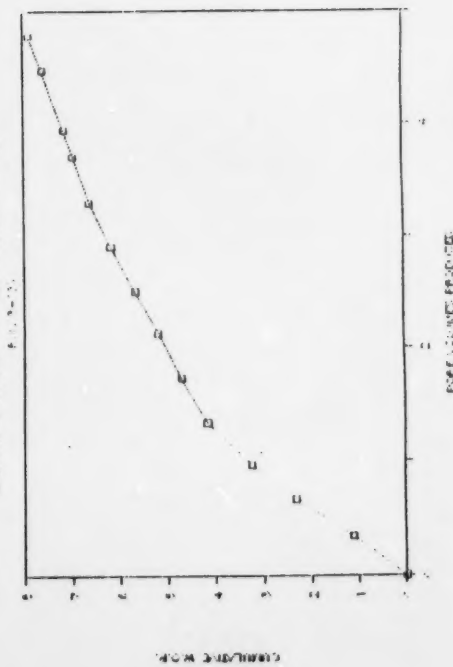


FIGURE 4.11

TEMPERATURE HISTORY

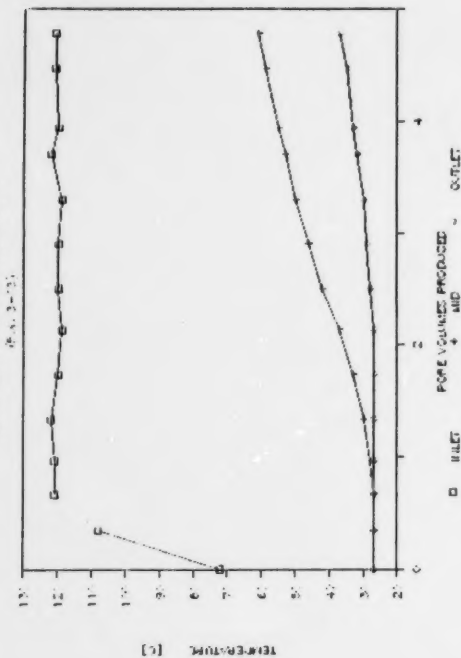


FIGURE 4.12

PRESSURE DROP HISTORY

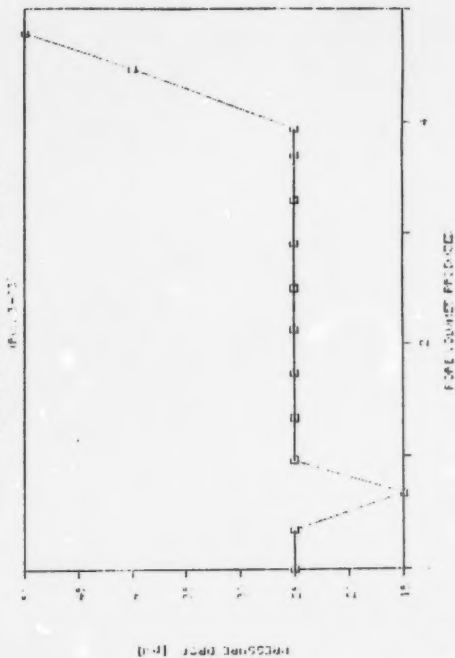


TABLE A-6

- 27 -

FIGURE 4.13

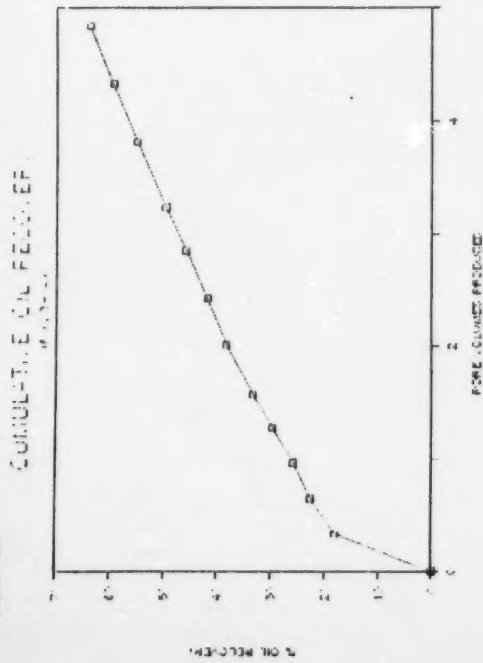


FIGURE 4.15

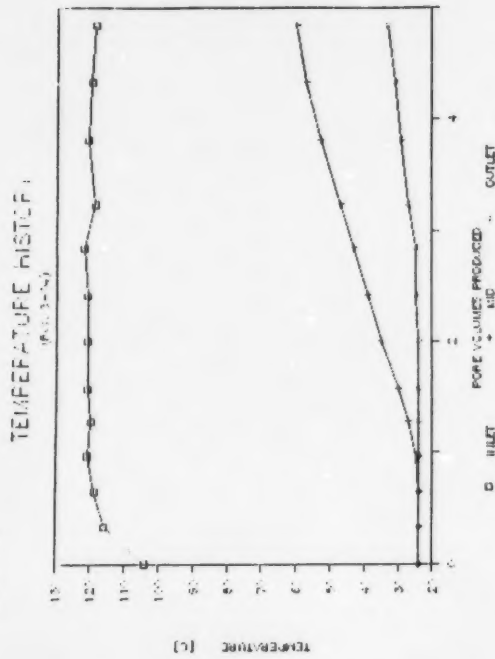


FIGURE 4.14

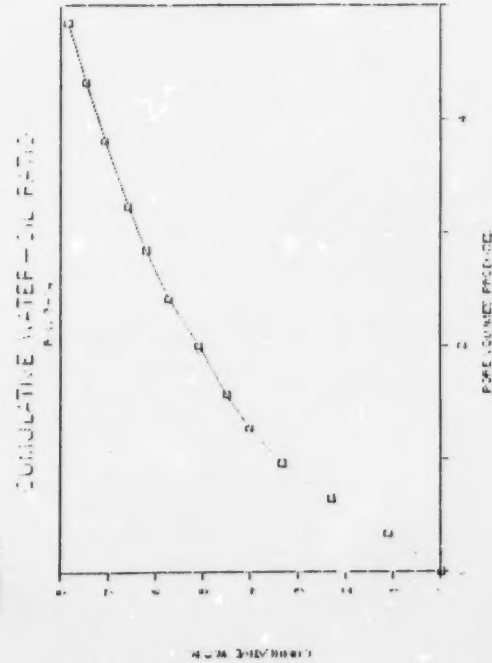


FIGURE 4.16

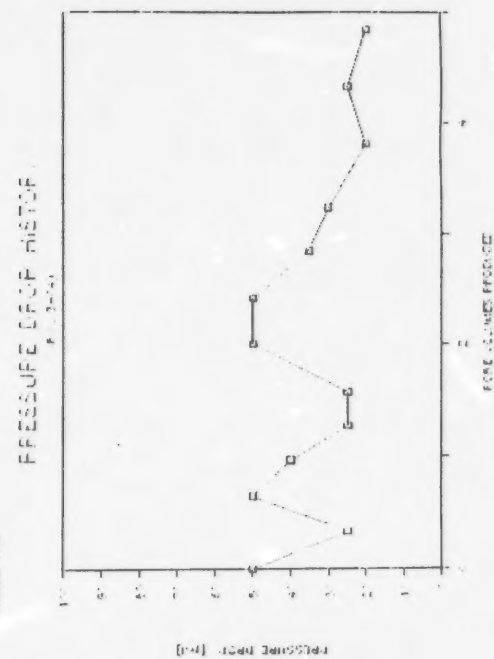


TABLE A-7

## 5. EFFECT OF OPERATING CONDITIONS ON THE HOT WATER/GAS PROCESS

### 5.1 **Experimental Conditions and General Results**

Oil displacement experiments to study the effect of operating conditions on the Hot Water/Gas process are discussed in this section. The operating variables of interest in this part of the investigation were:-

1. Injection water temperature
2. Water injection rate
3. Gas injection rate
4. Back pressure

A  $2^4$  factorial design of experiments has been followed to assess the effect of the operating variables. A symbolic tabulation of the set of experimental conditions is given in Table 5.1.

In all the experiments, identical core holder packing with 55 mesh Ottawa sand, water and oil core saturation procedures were consistently applied. In all the experiments, Pelican Lake oil and nitrogen gas were used.

The results of the set of sixteen experiments are shown in Figures 5.1 to 5.61. For each experimental run, the following characteristic curves are shown:-

- . Cumulative oil recovery
- . Cumulative water-oil ratio
- . Observed temperature profiles
- . History of observed pressures or pressure drop

No pressure profile is displayed for Run 4-4, 4-10 and 4-12, due to mechanical problems with the outlet pressure measurement, in each case.

Detailed statistical analysis performed on the data will be discussed in the next section. Several general observations, however, can be made with regard to the trends of the results:-

- . The results exhibit similar consistent trends in all the experiments.
- . Significant additional oil recovery is obtained due to gas injection.
- . An expected drop in the cumulative water-oil ratio accompanies gas injection.
- . The pressure profiles indicate that breakthrough takes place around 1 pore volume of hot water injection. A period of steady pressure drop is then generally observed. This is followed by further pressure drop reduction as the oil saturation is significantly reduced.
- . Oil recovery ranges between about 45 and 50% before nitrogen injection (at about 4 PV of water injection), and increases to 60-70% after gas injection.

- The injection of gas is consistently accompanied with a drop of the cumulative water-oil ratio. Thus, the cumulative water-oil ratio ranges between 7 to 9 before gas injection and drops to the range of 6 to 7 after the injection of nitrogen.
- A most significant observation is that the oil recoveries in this set of displacement experiments are comparable to those obtained in the steam runs, (see overall summary table).

A table summarizing the results of this series of runs (Table 5.4) is presented after the statistical analysis of the data.

TABLE 5.1

EFFECT OF OPERATING VARIABLES - EXPERIMENTAL CONDITIONS

| Experiment | Temperature<br>°C | Water Rate<br>mL/h | Gas Rate<br>L/h | Back Pressure<br>psig |
|------------|-------------------|--------------------|-----------------|-----------------------|
| 4-01       | T1                | W1                 | G1              | P1                    |
| 4-02       | T1                | W2                 | G1              | P1                    |
| 4-03       | T1                | W1                 | G2              | P1                    |
| 4-04       | T1                | W2                 | G2              | P1                    |
| 4-05       | T1                | W1                 | G1              | P2                    |
| 4-06       | T1                | W2                 | G1              | P2                    |
| 4-07       | T1                | W1                 | G2              | P2                    |
| 4-08       | T1                | W2                 | G2              | P2                    |
| 4-09       | T2                | W1                 | G1              | P1                    |
| 4-10       | T2                | W2                 | G1              | P1                    |
| 4-11       | T2                | W1                 | G2              | P1                    |
| 4-12       | T2                | W2                 | G2              | P1                    |
| 4-13       | T2                | W1                 | G1              | P2                    |
| 4-14       | T2                | W2                 | G1              | P2                    |
| 4-15       | T2                | W1                 | G2              | P2                    |
| 4-16       | T2                | W2                 | G2              | P2                    |

The nominal values selected for the above variables were:-

T1 and T2 are 100 and 150°C respectively

W1 and W2 are 530 and 1530 mL/h respectively

G1 and G2 are 36 and 177 L/h respectively

P1 and P2 are 200 and 100 psig respectively

FIGURE 5.1

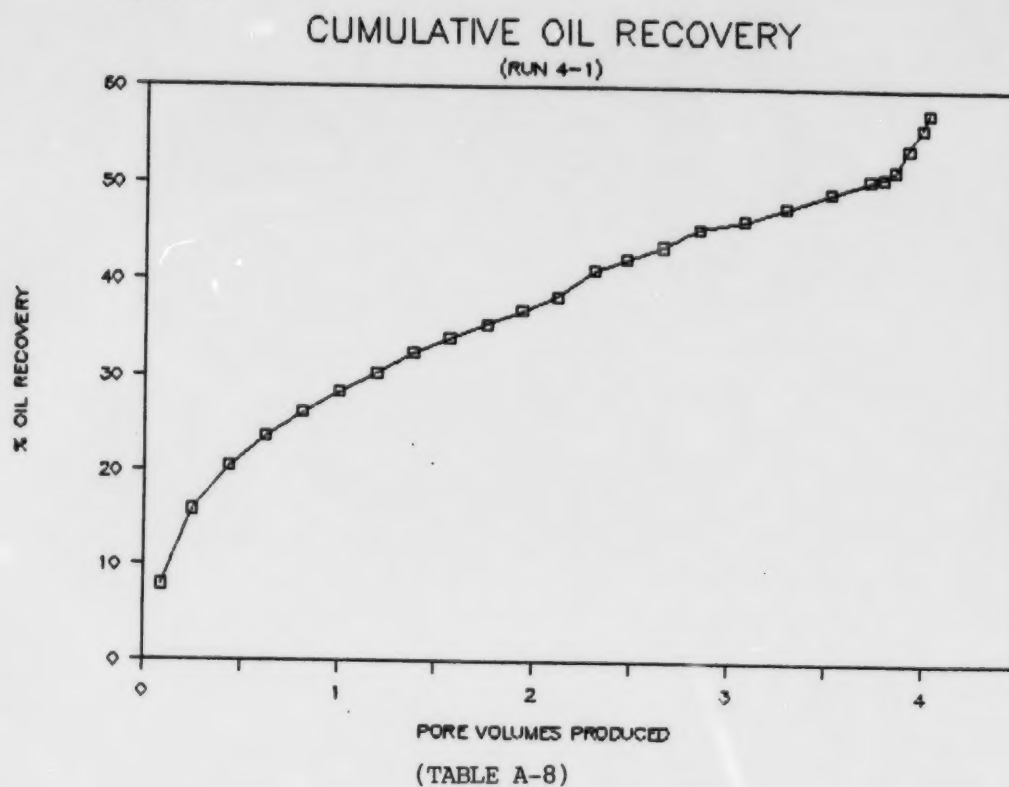


FIGURE 5.2

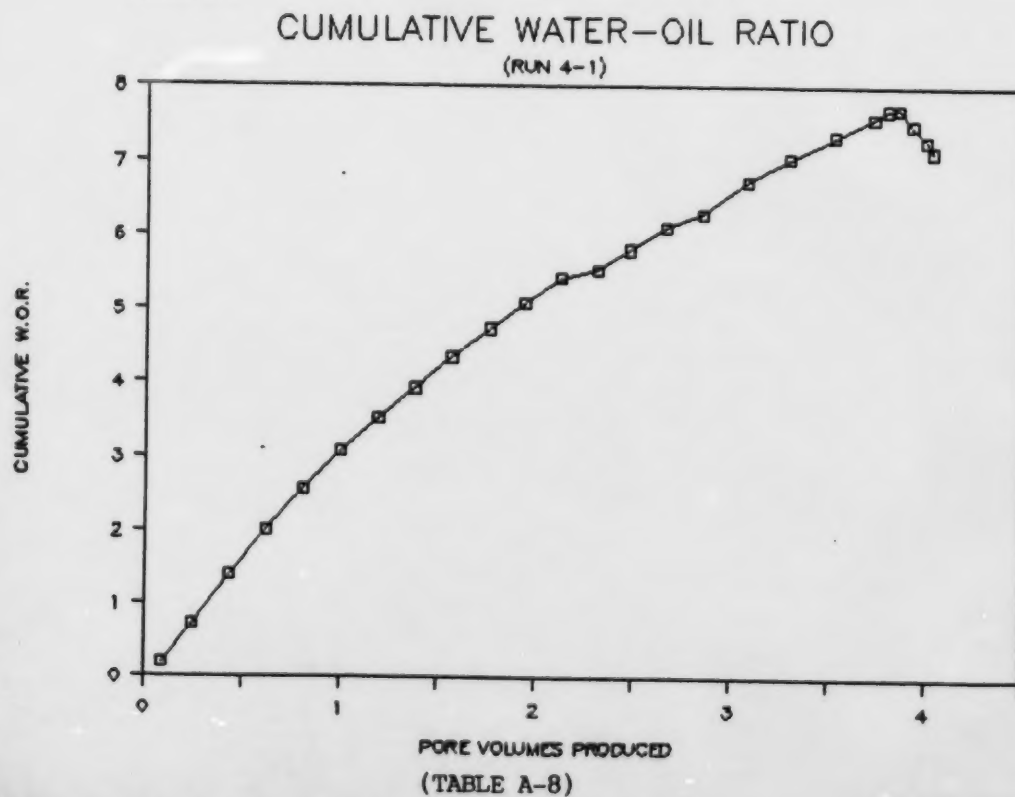
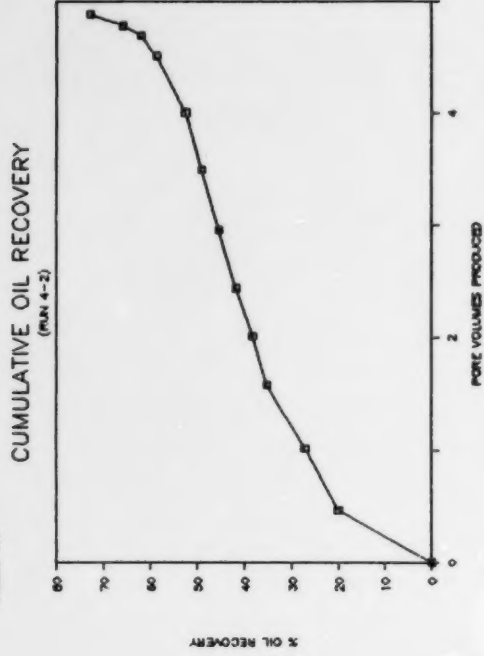
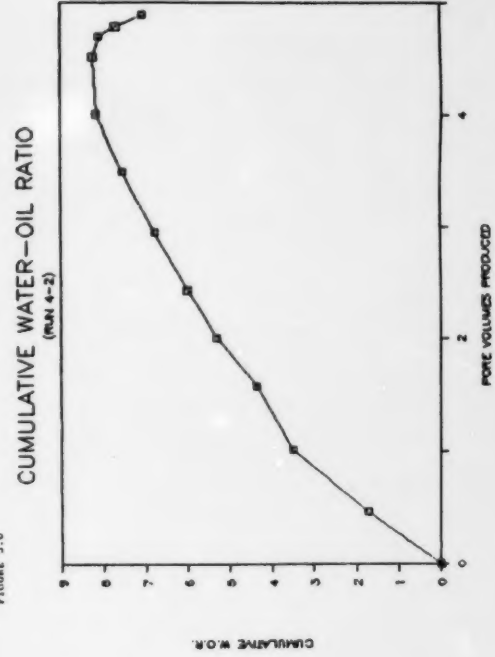


FIGURE 5.5



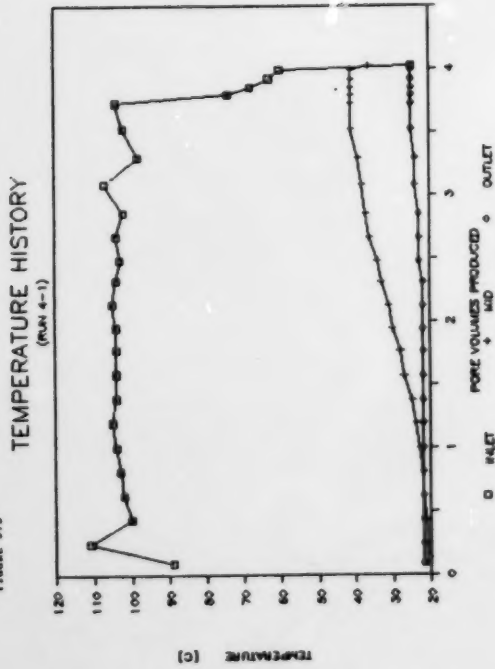
(TABLE A-9)

FIGURE 5.6



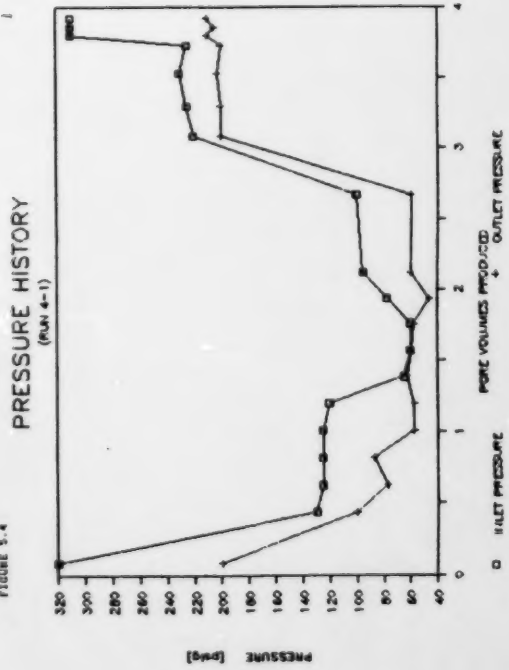
(TABLE A-9)

FIGURE 5.3



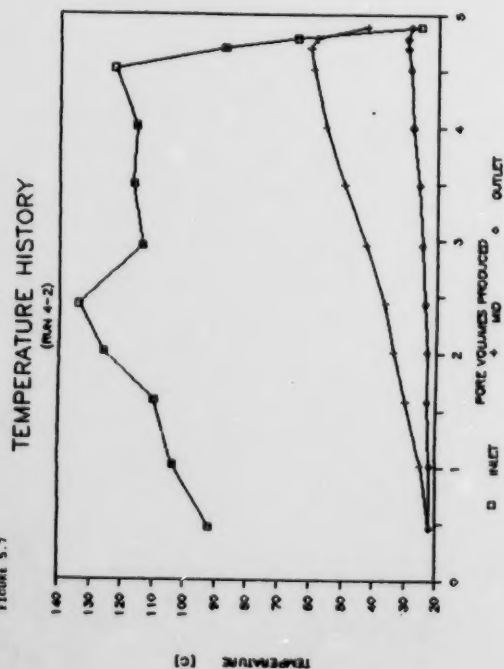
(TABLE A-8)

FIGURE 5.4



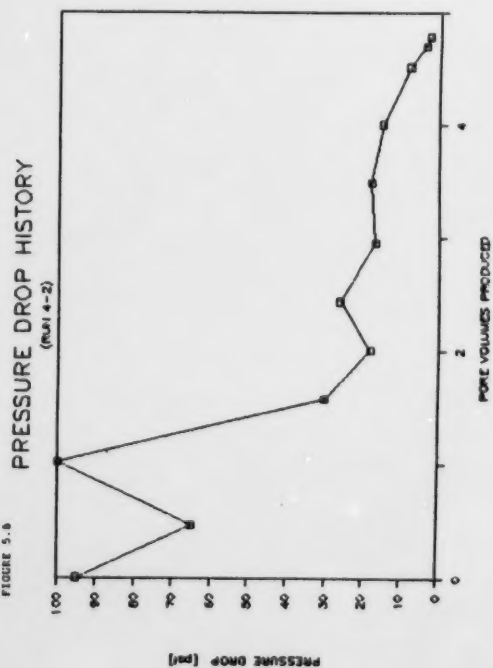
(TABLE A-8)

FIGURE 5.7



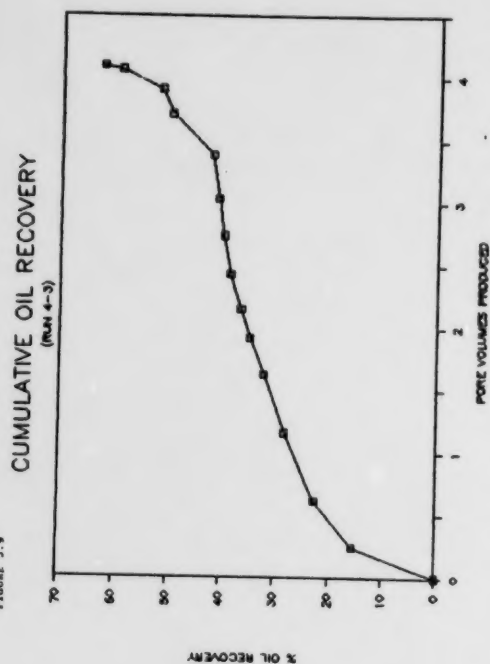
(TABLE A-9)

FIGURE 5.8



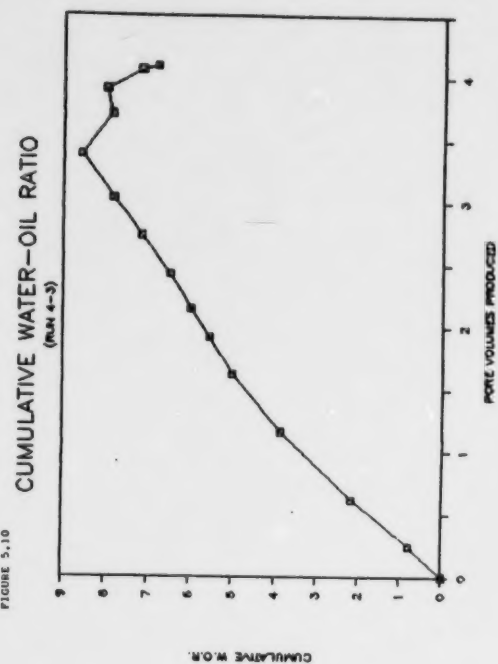
(TABLE A-9)

FIGURE 5.9



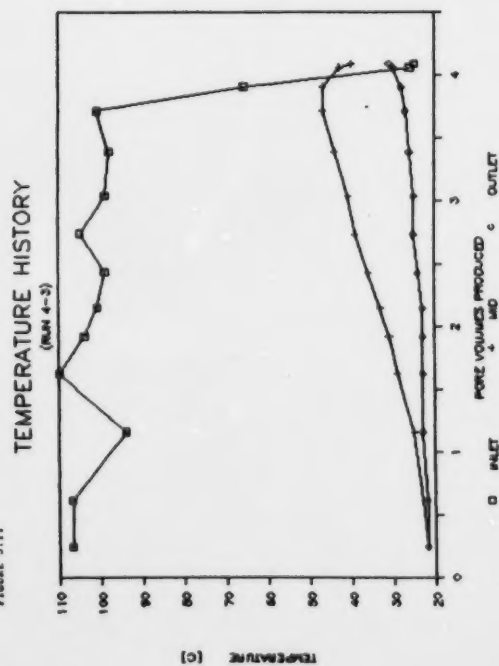
(TABLE A-10)

FIGURE 5.10



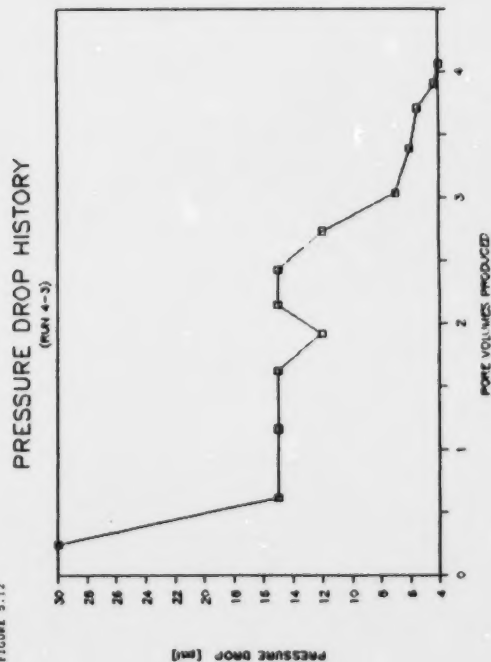
(TABLE A-10)

FIGURE 5.11



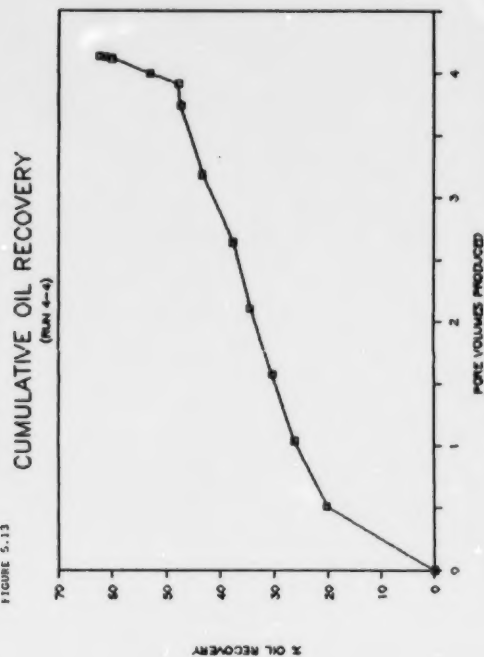
(TABLE A-10)

FIGURE 5.12



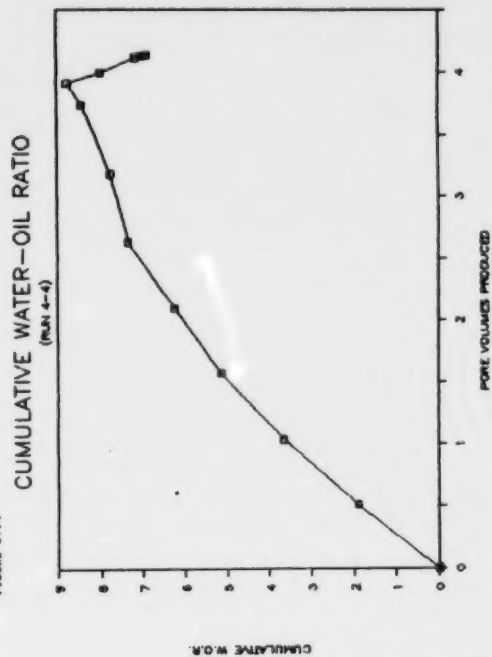
(TABLE A-10)

FIGURE 5.13



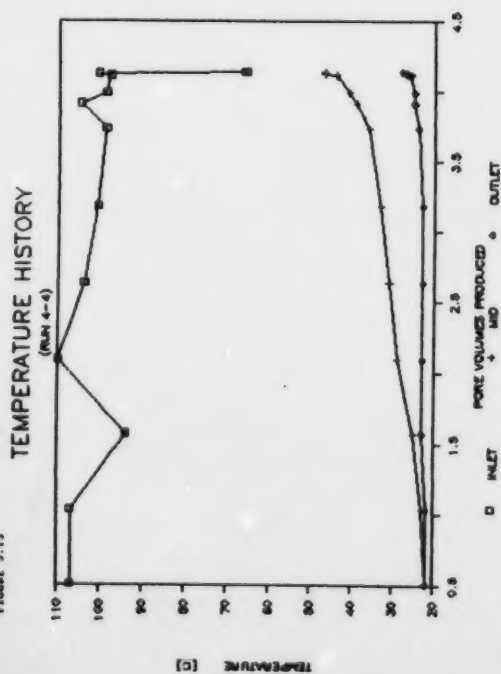
(TABLE A-11)

FIGURE 5.14



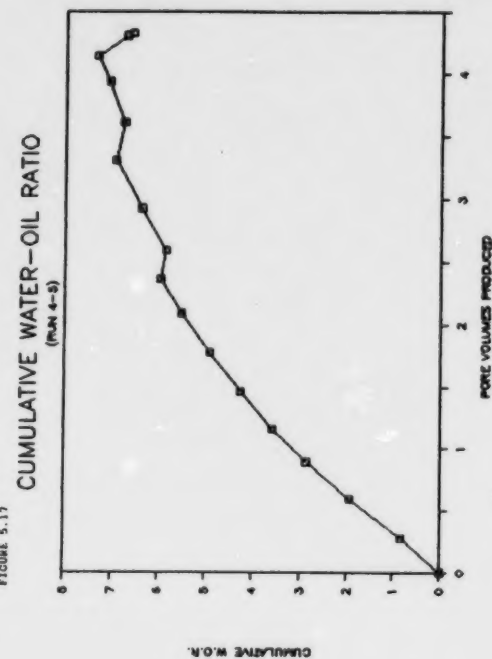
(TABLE A-11)

FIGURE 5.15



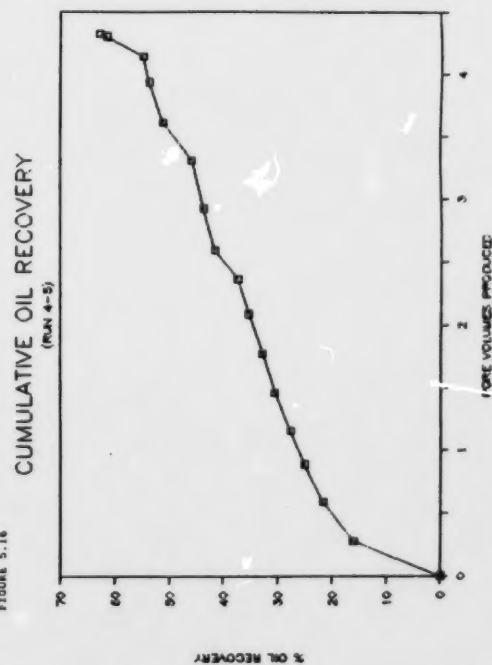
(TABLE A-11)

FIGURE 5.17



(TABLE A-12)

FIGURE 5.16



(TABLE A-12)

FIGURE 5.18

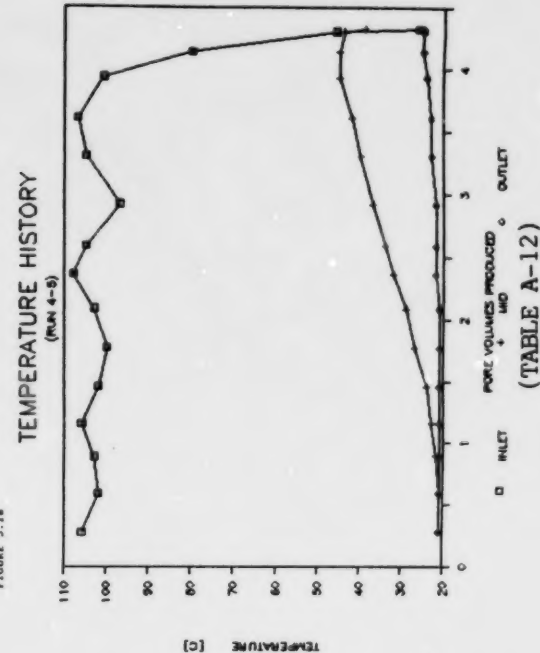
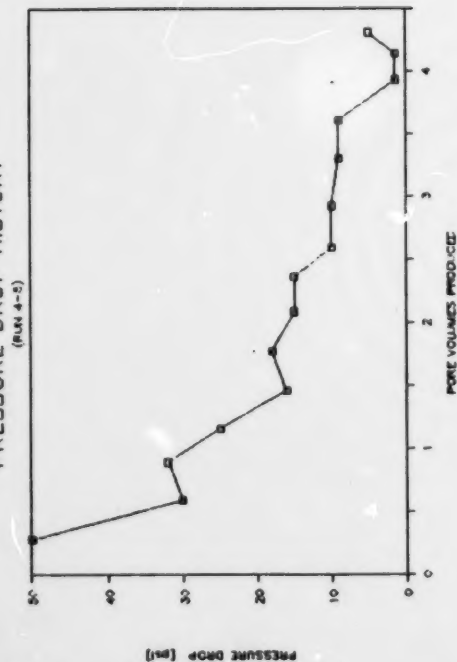


FIGURE 5.19

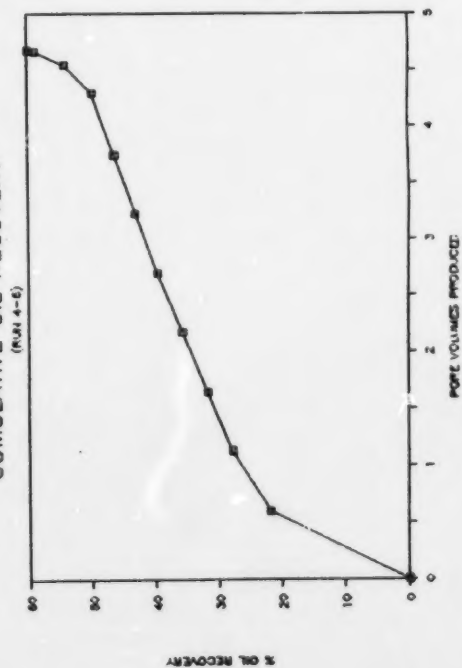
PRESSURE DROP HISTORY



(TABLE A-12)

FIGURE 5.20

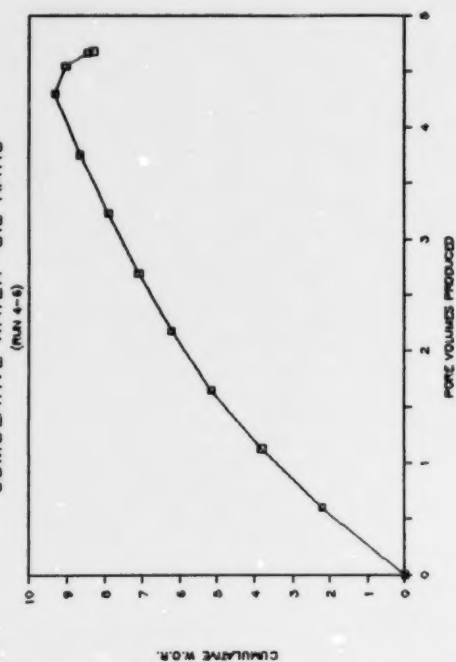
CUMULATIVE OIL RECOVERY



(TABLE A-13)

FIGURE 5.21

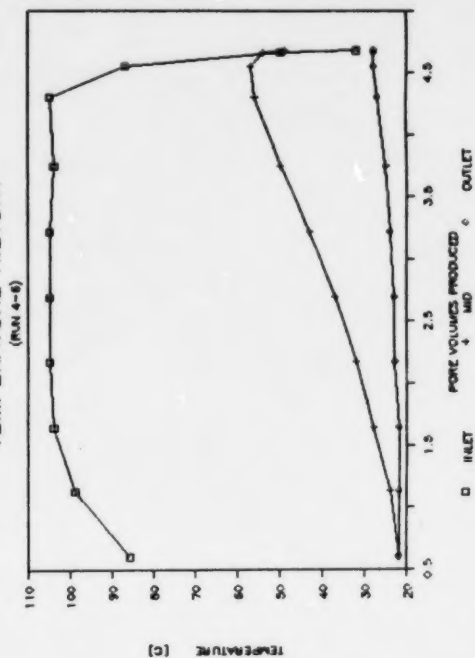
CUMULATIVE WATER-OIL RATIO



(TABLE A-13)

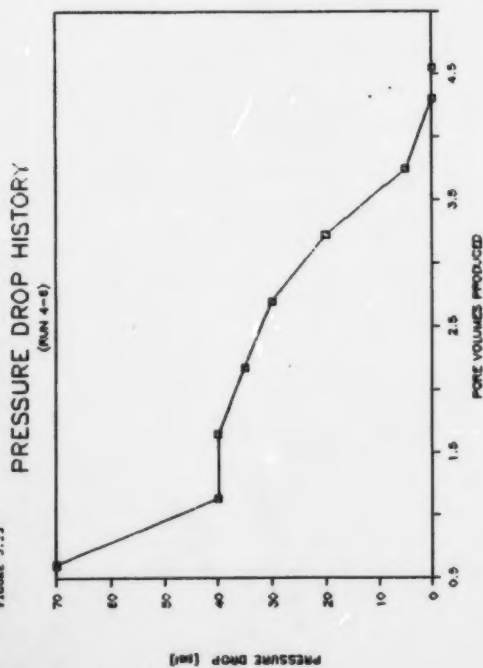
FIGURE 5.22

TEMPERATURE HISTORY



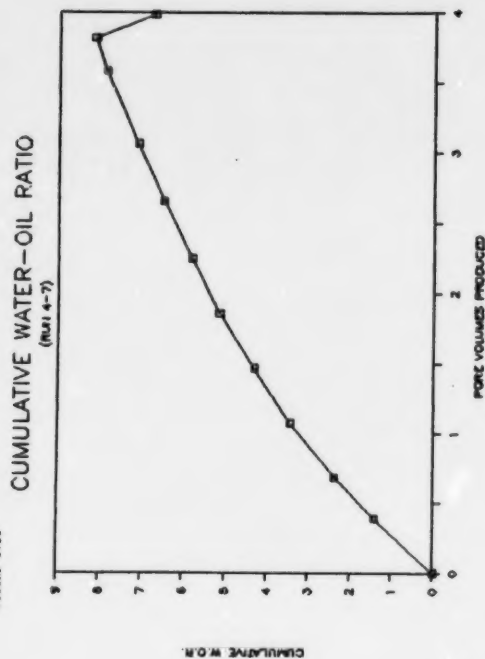
(TABLE A-13)

FIGURE 5.23



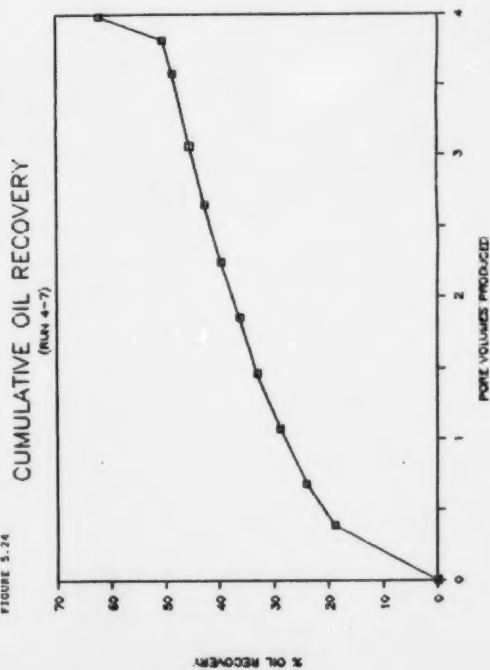
(TABLE A-13)

FIGURE 5.25



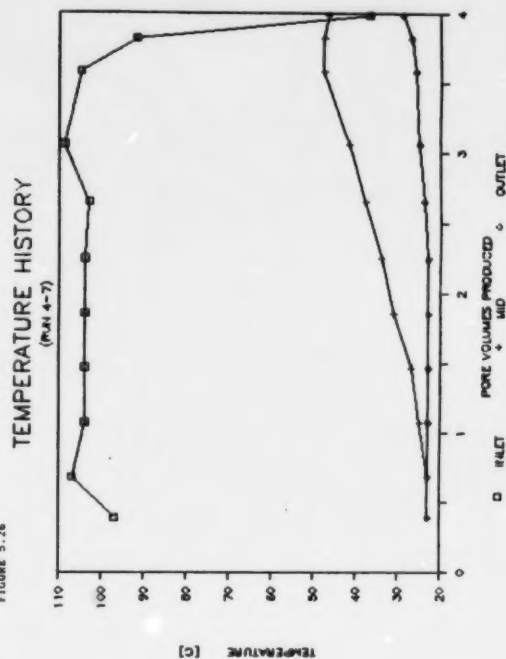
(TABLE A-14)

FIGURE 5.24



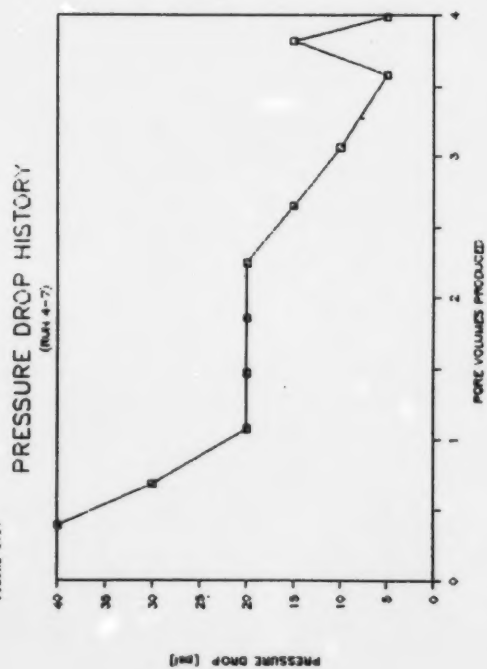
(TABLE A-14)

FIGURE 5.26



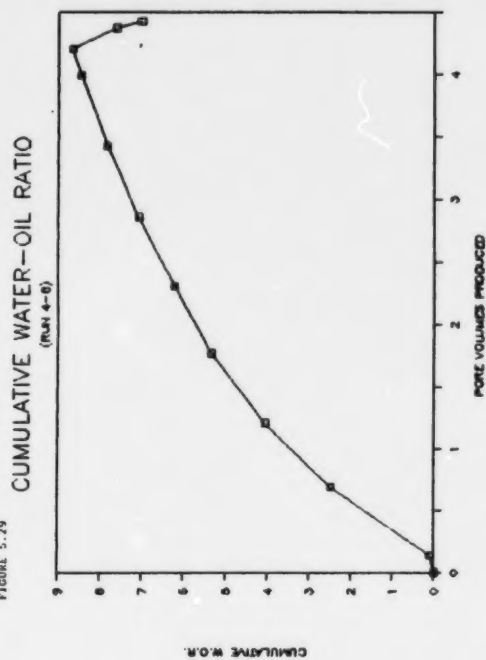
(TABLE A-14)

FIGURE 5.27



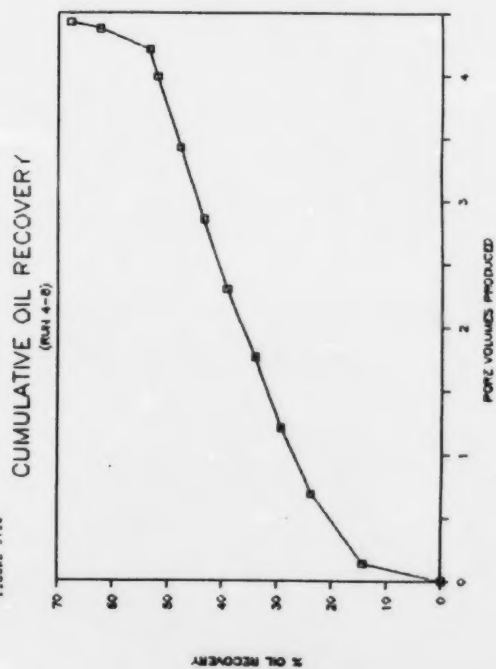
(TABLE A-14)

FIGURE 5.29



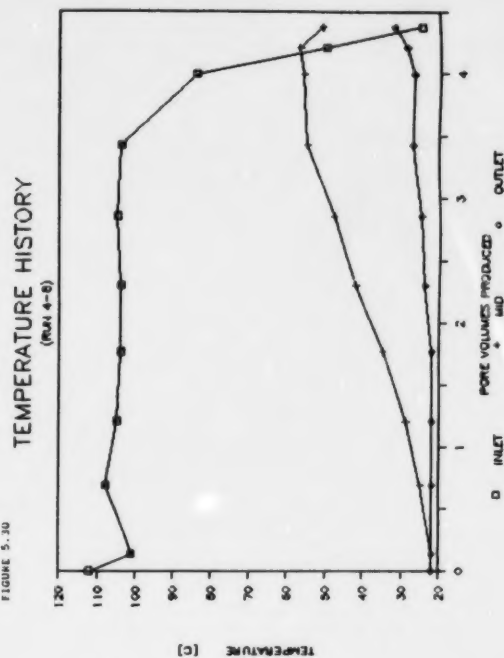
(TABLE A-15)

FIGURE 5.28



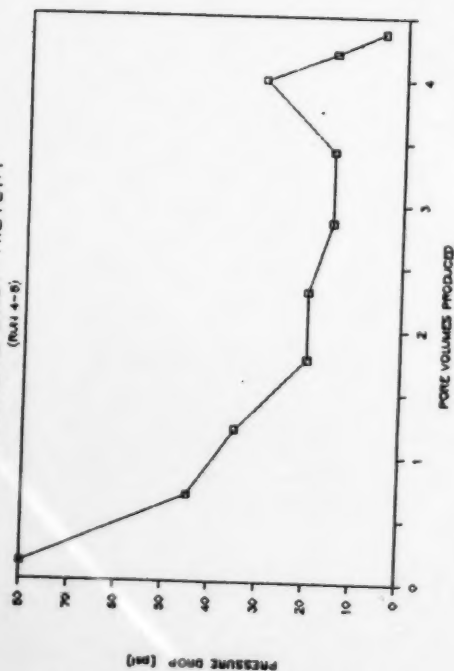
(TABLE A-15)

FIGURE 5.30



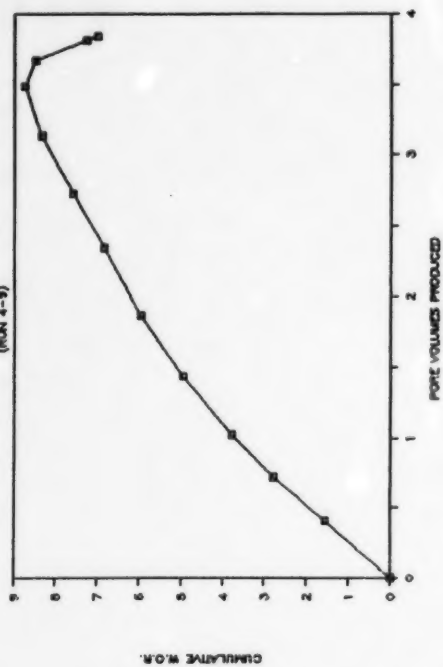
(TABLE A-15)

FIGURE 5.31  
PRESSURE DROP HISTORY  
(RUN 4-9)



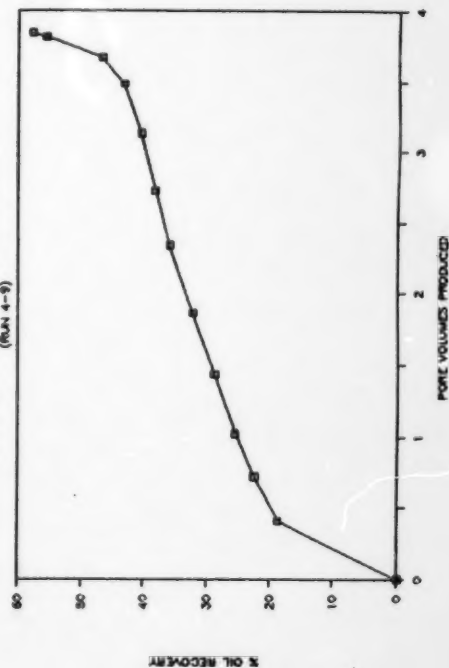
(TABLE A-15)

FIGURE 5.33  
CUMULATIVE WATER-OIL RATIO  
(RUN 4-9)



(TABLE A-16)

FIGURE 5.32  
CUMULATIVE OIL RECOVERY  
(RUN 4-9)



(TABLE A-16)

FIGURE 5.34  
TEMPERATURE HISTORY  
(RUN 4-9)

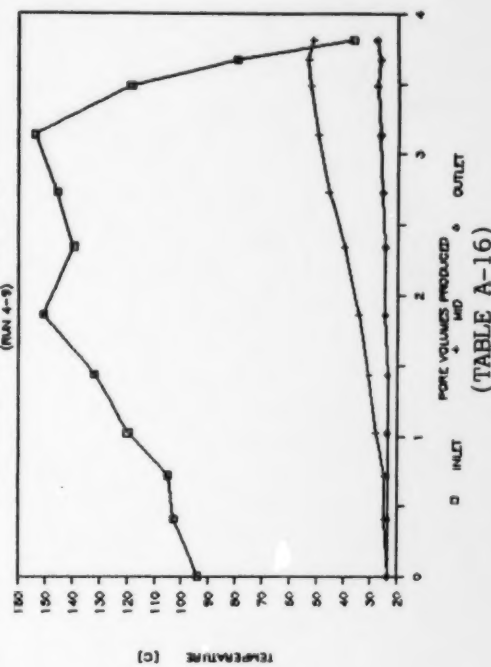
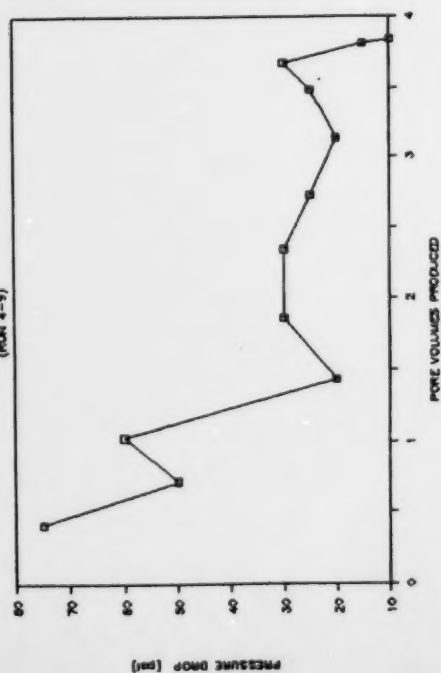


FIGURE 5.35

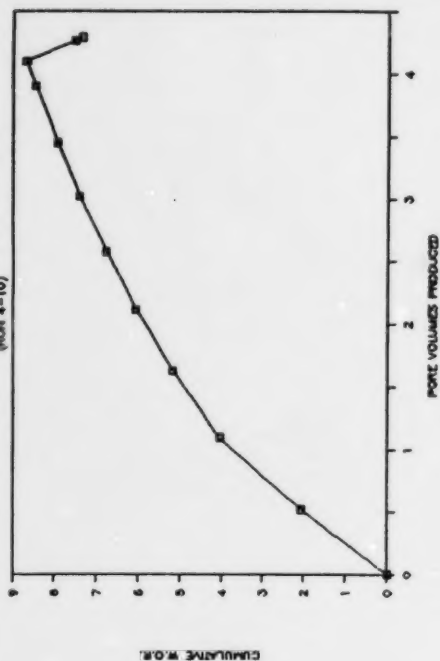
PRESSURE DROP HISTORY  
(RUN 4-9)



(TABLE A-16)

FIGURE 5.37

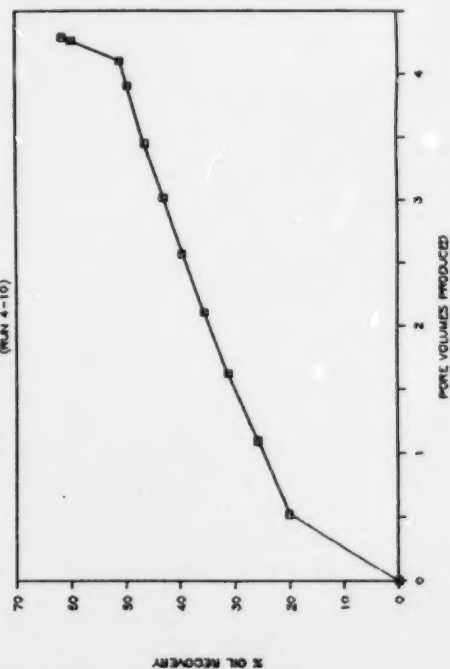
CUMULATIVE WATER-OIL RATIO  
(RUN 4-10)



(TABLE A-17)

FIGURE 5.36

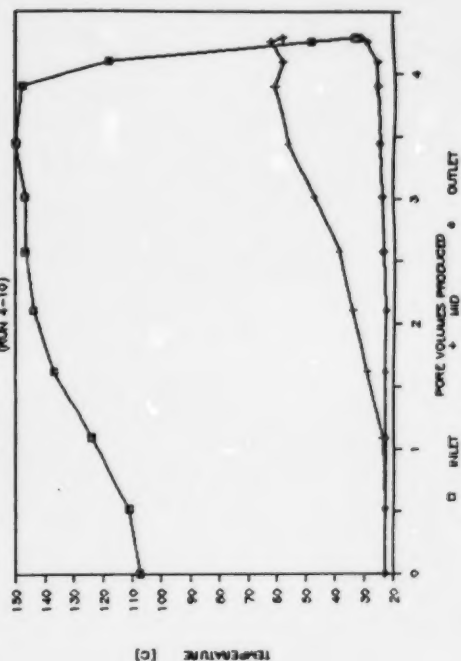
CUMULATIVE OIL RECOVERY  
(RUN 4-10)



(TABLE A-17)

FIGURE 5.38

TEMPERATURE HISTORY  
(RUN 4-10)



(TABLE A-17)

FIGURE 5.39

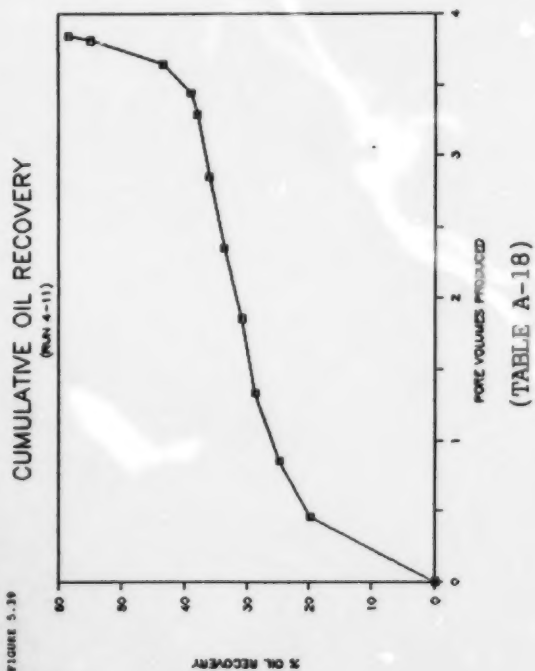


FIGURE 5.41

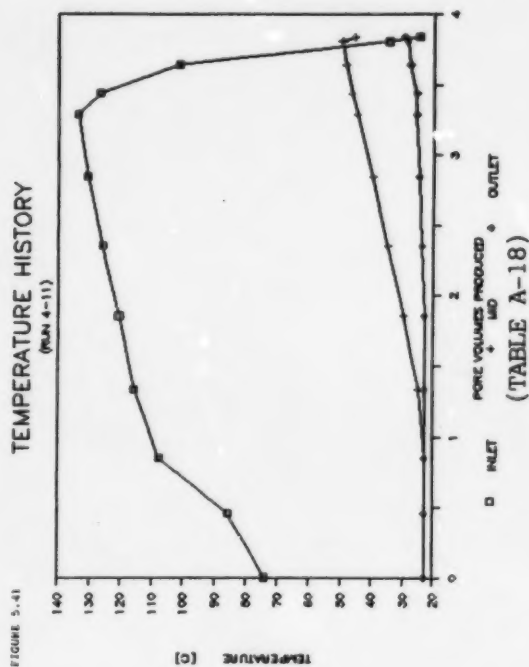


FIGURE 5.40

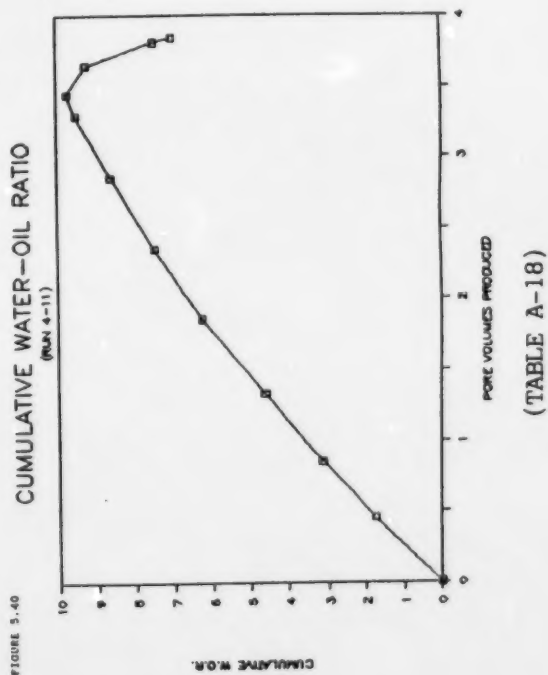
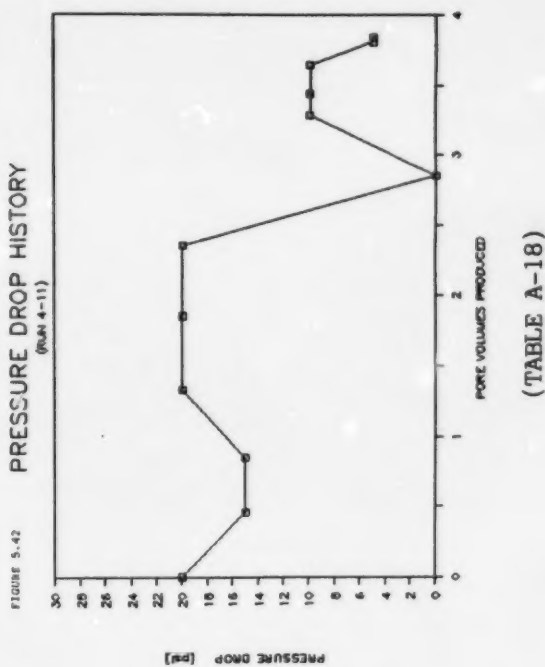


FIGURE 5.42



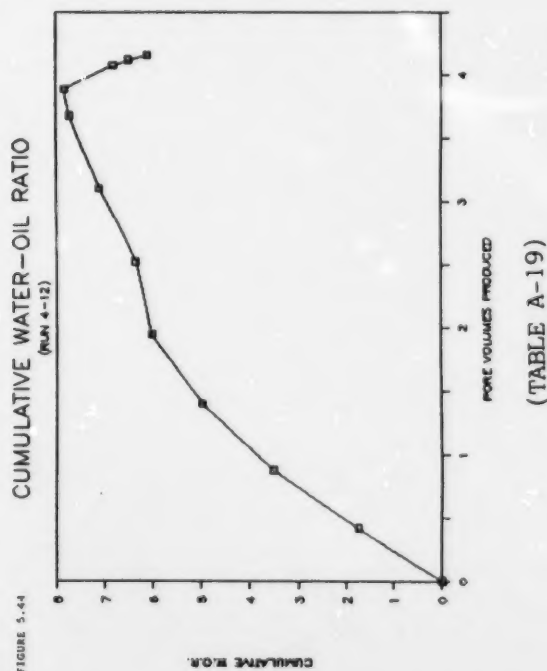
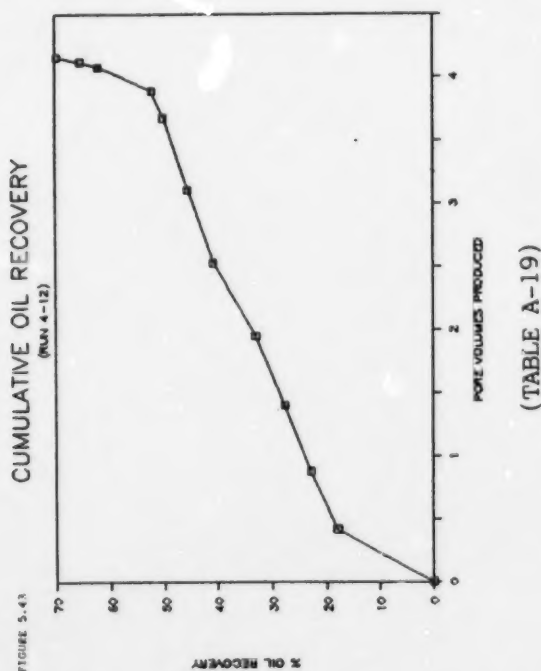
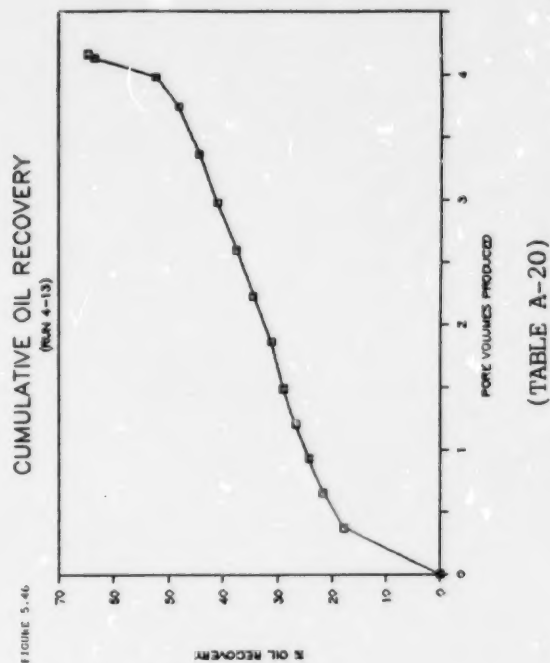
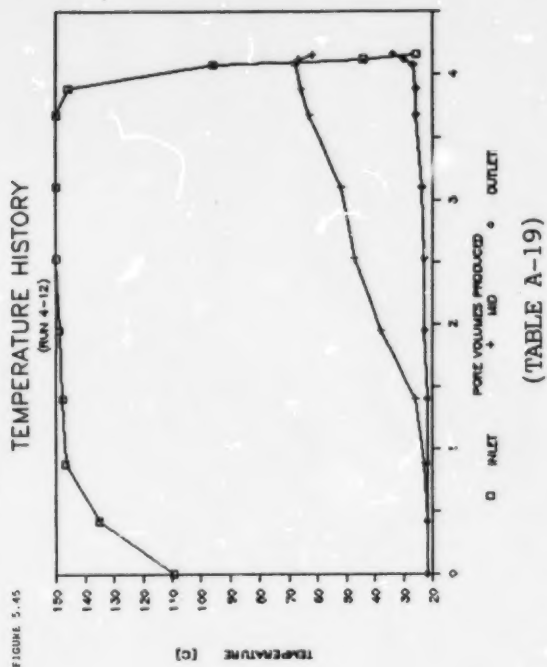
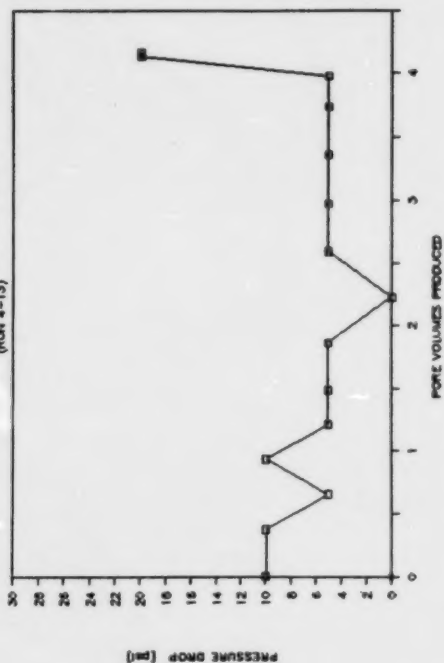
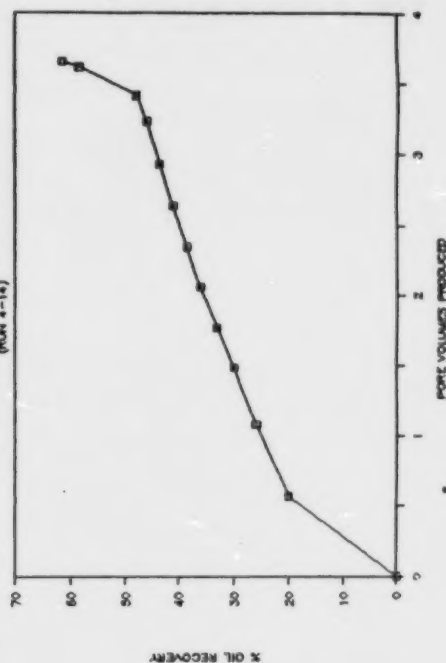


FIGURE 5.49 PRESSURE DROP HISTORY  
(RUN 4-13)



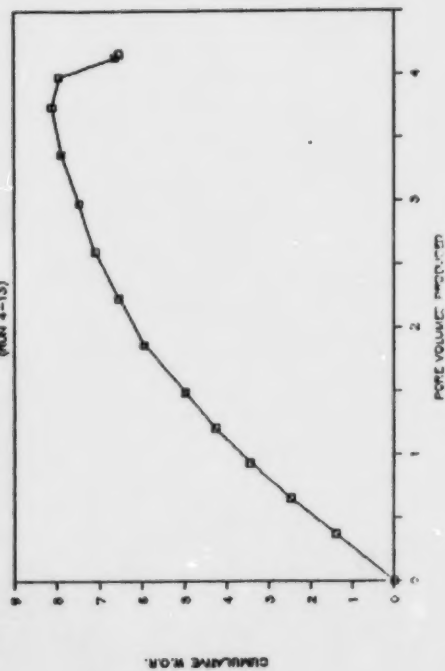
(TABLE A-20)

FIGURE 5.50 CUMULATIVE OIL RECOVERY  
(RUN 4-14)



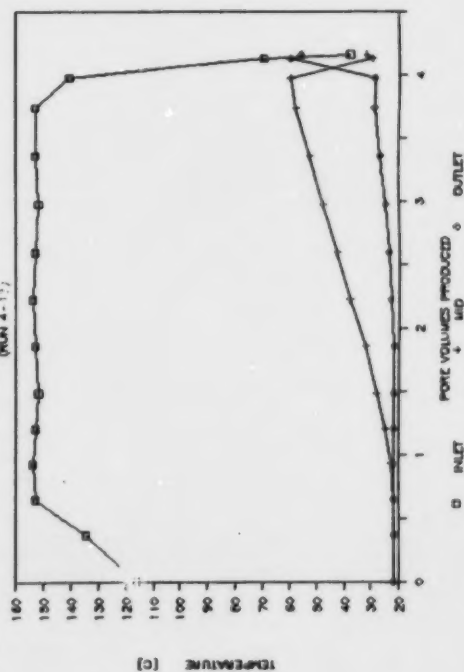
(TABLE A-21)

FIGURE 5.47 CUMULATIVE WATER-OIL RATIO  
(RUN 4-13)



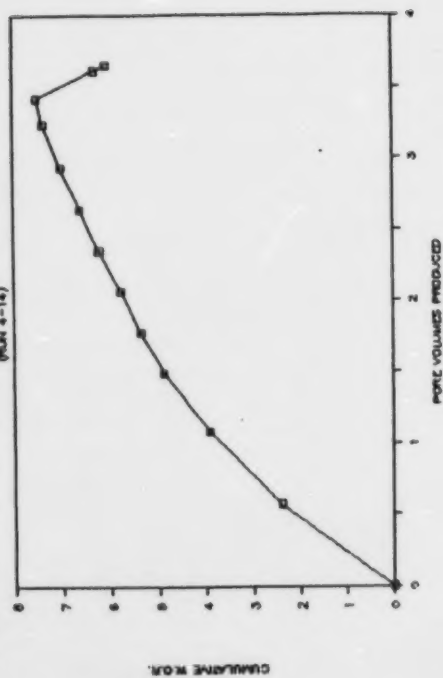
(TABLE A-20)

FIGURE 5.48 TEMPERATURE HISTORY  
(RUN 4-17)



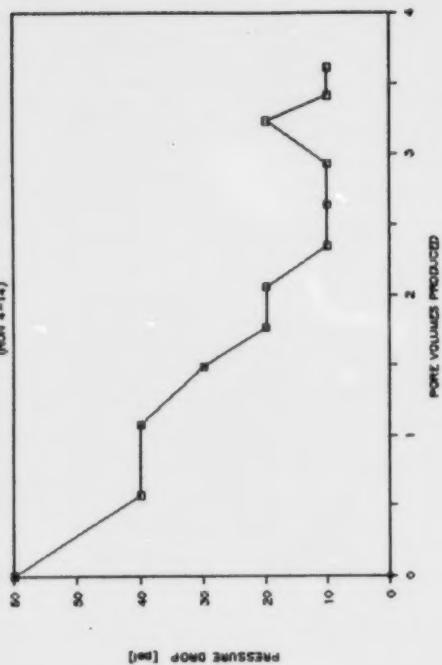
(TABLE A-20)

FIGURE 5.51  
(RUN 4-14)



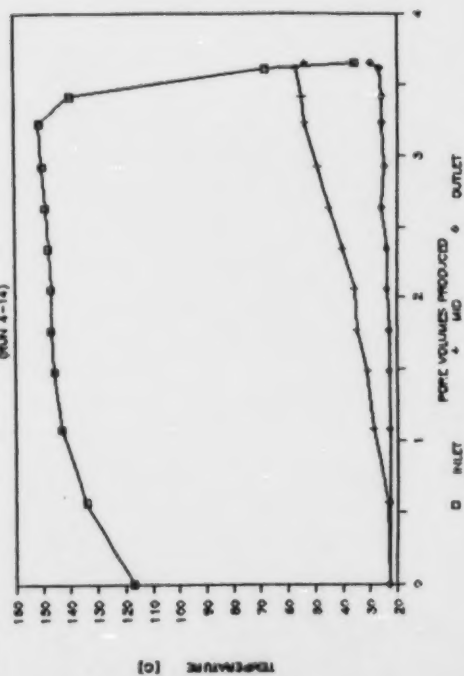
(TABLE A-21)

FIGURE 5.53  
(RUN 4-14)



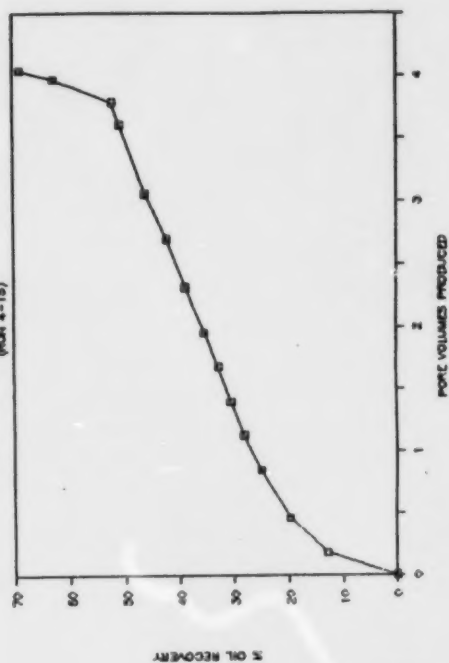
(TABLE A-21)

FIGURE 5.52  
(RUN 4-14)



(TABLE A-21)

FIGURE 5.54  
(RUN 4-15)



(TABLE A-22)

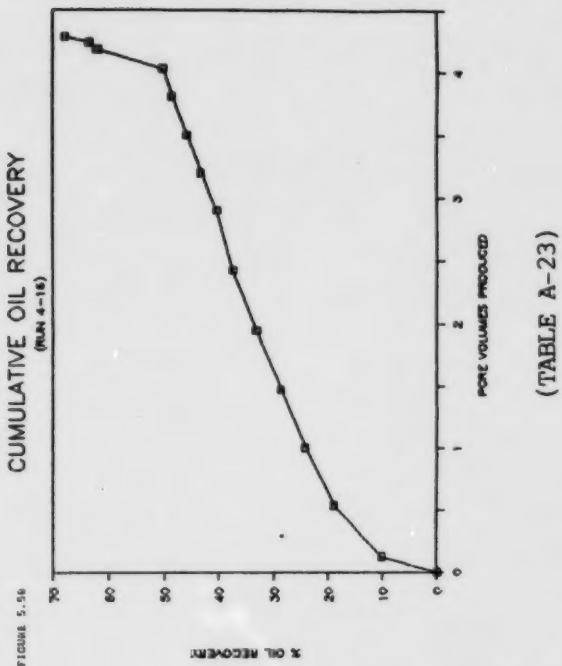
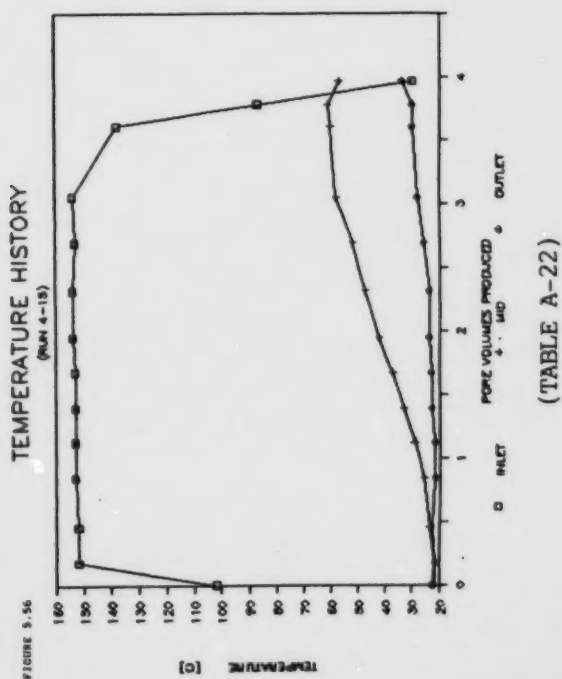
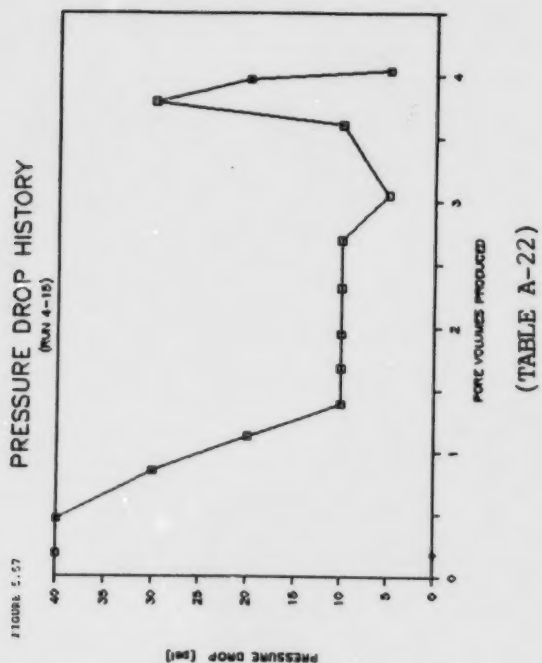
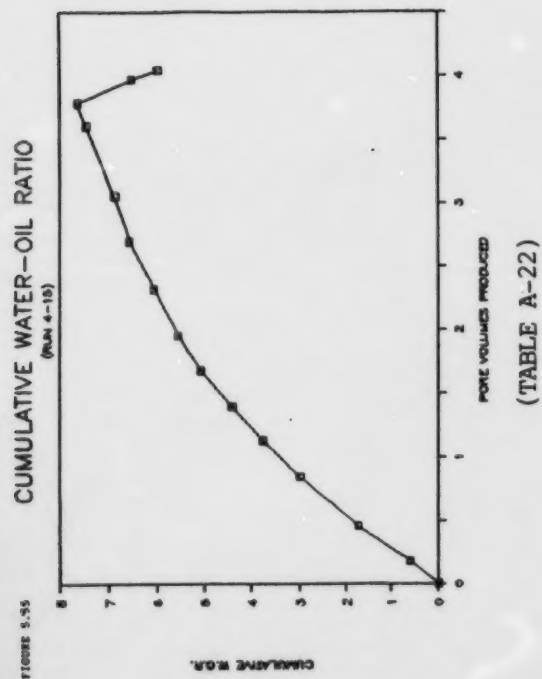


FIGURE 5.59 CUMULATIVE WATER-OIL RATIO

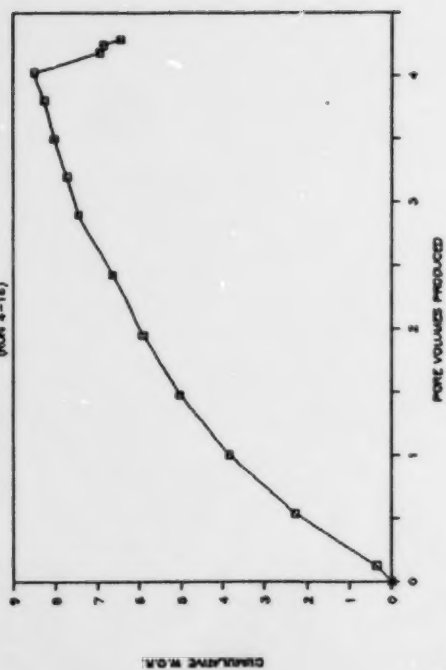


FIGURE 5.61 PRESSURE DROP HISTORY

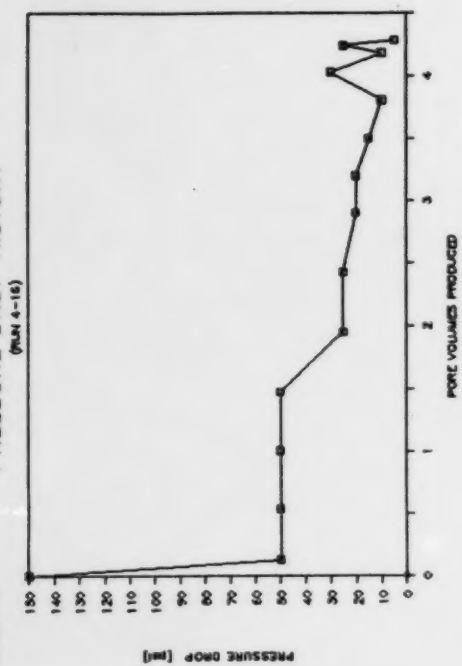
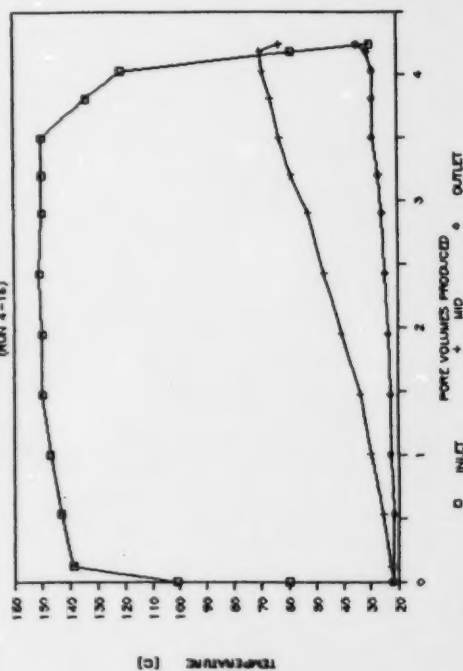


FIGURE 5.60 TEMPERATURE HISTORY



(TABLE A-23)

## 5.2 Statistical Analysis of Data

Facing the large volume of data typically generated in oil displacement experiments, it was important to select a parameter, or a small set of parameters, which would enable a meaningful statistical analysis of the laboratory experiments. In the reported set of experiments, such a parameter, or set of parameters, must reflect an accurate picture of the oil recovery enhancement mechanism resulting from gas injection after the hot water displacement. The ultimate oil recovery, or water-oil ratio, could not be used as such characteristic parameter(s). The reason being that the injection conditions, particularly the volumes of fluids injected and the moment of switching from hot water to gas injection, varied somewhat from run to run. Oil recovery, or water-oil ratio, corresponding to a certain number of pore volumes injected could not be used for similar reasons.

Reviewing the oil recovery profiles, however, reveals that the oil recovery rate just before and after switching from hot water to gas injection can give a clear indication of oil recovery enhancement. Thus an oil recovery enhancement index (OREI) was defined as the ratio of the slopes of the two line segments after and before switching to gas injection. It is clear from all the data that the slope of the line segment, of the oil recovery curve, during gas injection was generally significantly larger than the preceding line segments. Therefore the value of OREI would always be greater than 1 for such experimental conditions.

To calculate OREI, straight lines were fitted to the indicated line segments, the slope of each segment was statistically calculated, and the ratio of the two slopes obtained. The calculated value of OREI, for the entire set of experiments, Runs 4-1 to 4-16, are given in Table 5.2. These values were used as the basis for the analysis of variance.

As indicated in the previous section, the group of experiments were planned to give a full set of  $2^4$  factorial design. The four variables are the water injection temperature, the water injection rate, the gas injection rate, and back pressure. Each of the variables was considered at two levels as listed in Table 5.1. Analysis of variance was carried out on the entire  $2^4$  set, considering first order interactions between the main effects. The analysis of variance is detailed in Tables 5.3 (A through N). Table (A) shows the calculated oil recovery enhancement index OREI corresponding to each set of experimental conditions, the sum of squares corresponding to each variable, grand sum of squares, correction for the sum of squares, and total variance. Standard analysis of variance is subsequently followed, considering all the first order interactions of the main effects. Interaction tables are listed in Tables B to G. The corresponding interactions ANOVA tables are H to M; they show the degrees of freedom, sum of squares and calculated mean squares. Table (N) summarizes the analysis of variance. It also shows the F-tests considered for the main effect.

It is clear from the analysis, that only the temperature effect is statistically significant (Table N) at the 95% confidence level. None of the other effects (pressure, water injection rate, or gas injection rate) is significant in the range of experimental conditions examined.

TABLE 5.2

EFFECT OF OPERATING VARIABLES/OIL RECOVERY  
ENHANCEMENT INDEX

| <u>EXPERIMENT</u> | <u>OREI</u> |
|-------------------|-------------|
| 4-01              | 4.4         |
| 4-02              | 5.8         |
| 4-03              | 4.1         |
| 4-04              | 7.3         |
| 4-05              | 4.1         |
| 4-06              | 4.2         |
| 4-07              | 5.8         |
| 4-08              | 4.6         |
| 4-09              | 10.0        |
| 4-10              | 7.3         |
| 4-11              | 9.7         |
| 4-12              | 7.3         |
| 4-13              | 7.5         |
| 4-14              | 6.9         |
| 4-15              | 6.8         |
| 4-16              | 7.7         |

## ANALYSIS OF VARIANCE TABLES

EFFECT OF OPERATING VARIABLES  
\*\*\*\*\*

TABLE (A)

ANOVA TABLE

|                   |    | T1       | T1   | T2   | T2   |
|-------------------|----|----------|------|------|------|
|                   |    | P1       | P2   | P1   | P2   |
| W1                | G1 | 4.4      | 4.1  | 10   | 7.5  |
| W1                | G2 | 4.1      | 5.8  | 9.7  | 6.8  |
| W2                | G1 | 5.8      | 4.2  | 7.3  | 6.9  |
| W2                | G2 | 7.3      | 4.6  | 7.3  | 7.7  |
| SUM COLUMNS       |    | 21.6     | 18.7 | 34.3 | 28.9 |
| SUM TEMPERATURES: |    | T1=      | 40.3 | T2=  | 63.2 |
| SUM PRESSURES:    |    | P1=      | 55.9 | P2=  | 47.6 |
| SUM WATER RATES:  |    | W1=      | 52.4 | W2=  | 51.1 |
| SUM GAS RATES:    |    | G1=      | 50.2 | G2=  | 53.3 |
| GRAND SUM         |    | 103.5    |      |      |      |
| CORRECTION        |    | 669.5156 |      |      |      |
| TOTAL VARIANCE SS |    | 52.89437 |      |      |      |

TABLE (B)

| INTERACTION TABLE |          | TEMPERATURE X PRESSURE |      | SUM TEMPS |
|-------------------|----------|------------------------|------|-----------|
| TEMPERATURE       | P1       | P2                     |      |           |
| T1                | 21.6     | 18.7                   | 40.3 |           |
| T2                | 34.3     | 28.9                   | 63.2 |           |
| SUM PRESSURES     | 55.9     | 47.6                   |      |           |
| SS [TOT] =        | 37.47187 |                        |      |           |
| SS [TEMP] =       | 32.77562 |                        |      |           |
| SS [PRESS] =      | 4.305625 |                        |      |           |

TABLE (C)

| INTERACTION TABLE |  | TEMPERATURE X WATER RATE |      | SUM TEMPS |
|-------------------|--|--------------------------|------|-----------|
|                   |  | W. RATE                  |      |           |
| TEMPERATURE       |  | W1                       | W2   |           |
| T1                |  | 18.4                     | 21.9 | 40.3      |
| T2                |  | 34                       | 29.2 | 63.2      |
| SUM WATER RATES   |  | 52.4                     | 51.1 |           |
| SS [TOT] =        |  | 37.18687                 |      |           |
| SS [TEMP] =       |  | 32.77562                 |      |           |
| SS [W-RATE] =     |  | 0.105625                 |      |           |

TABLE (D)

| INTERACTION TABLE |  | TEMPERATURE X GAS RATE |      | SUM TEMPS |
|-------------------|--|------------------------|------|-----------|
|                   |  | GAS RATE               |      |           |
| TEMPERATURE       |  | G1                     | G2   |           |
| T1                |  | 18.5                   | 21.8 | 40.3      |
| T2                |  | 31.7                   | 31.5 | 63.2      |
| SUM GAS RATES     |  | 50.2                   | 53.3 |           |
| SS [TOT] =        |  | 34.14187               |      |           |
| SS [TEMP] =       |  | 32.77562               |      |           |
| SS [G-RATE] =     |  | 0.600625               |      |           |

TABLE (E)

| INTERACTION TABLE |  | PRESSURE X WATER RATE |      | SUM PRESS |
|-------------------|--|-----------------------|------|-----------|
|                   |  | W. RATE               |      |           |
| PRESSURE          |  | W1                    | W2   |           |
| P1                |  | 28.2                  | 27.7 | 55.9      |
| P2                |  | 24.2                  | 23.4 | 47.6      |
| SUM WATER RATES   |  | 52.4                  | 51.1 |           |
| SS [TOT] =        |  | 4.416875              |      |           |
| SS [PRESS] =      |  | 4.305625              |      |           |
| SS [W-RATE] =     |  | 0.105625              |      |           |

TABLE (F)

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| INTERACTION TABLE |          | PRESSURE X GAS RATE |  | SUM PRESS |
|-------------------|----------|---------------------|--|-----------|
|                   |          | GAS RATE            |  |           |
| PRESSURE          | G1       | G2                  |  |           |
| P1                | 27.5     | 28.4                |  | 55.9      |
| P2                | 22.7     | 24.9                |  | 47.6      |
| SUM GAS RATES     | 50.2     | 53.3                |  |           |
|                   |          |                     |  |           |
| SS [TOT] =        | 5.011875 |                     |  |           |
| SS [PRESS] =      | 4.305625 |                     |  |           |
| SS [G-RATE] =     | 0.600625 |                     |  |           |

TABLE (G)

| INTERACTION TABLE |          | WATER RATE X GAS RATE |  | SUM W.RAT |
|-------------------|----------|-----------------------|--|-----------|
|                   |          | GAS RATE              |  |           |
| WATER RATE        | G1       | G2                    |  |           |
| W1                | 26       | 26.4                  |  | 52.4      |
| W2                | 24.2     | 26.9                  |  | 51.1      |
| SUM GAS RATES     | 50.2     | 53.3                  |  |           |
| SS [TOT] =        | 1.036875 |                       |  |           |
| SS [W-RATE] =     | 0.105625 |                       |  |           |
| SS [G-RATE] =     | 0.600625 |                       |  |           |

TABLE (H)

| TEMPERATURE X PRESSURE ANOVA TABLE |    |          |          |
|------------------------------------|----|----------|----------|
| SOURCE                             | df | SS       | MS       |
| BETWEEN TEPPERATURES               | 1  | 32.77562 | 32.77562 |
| BETWEEN PRESSURES                  | 1  | 4.305625 | 4.305625 |
| TEMP X PRESS INTERACTION           | 1  | 0.390625 | 0.390625 |
|                                    | 3  | 37.47187 |          |

TABLE (I)

| TEMPERATURE X WATER-RATE ANOVA TABLE |    |          |          |
|--------------------------------------|----|----------|----------|
| SOURCE                               | df | SS       | MS       |
| BETWEEN TEPPERATURES                 | 1  | 32.77562 | 32.77562 |
| BETWEEN WATER RATES                  | 1  | 0.105625 | 0.105625 |
| TEMP X W-RATE INTERACTION            | 1  | 4.305625 | 4.305625 |
|                                      | 3  | 37.18687 |          |

TABLE (J)

| TEMPERATURE X GAS-RATE ANOVA TABLE |    |          |          |
|------------------------------------|----|----------|----------|
| SOURCE                             | df | SS       | MS       |
| BETWEEN TEPPERATURES               | 1  | 32.77562 | 32.77562 |
| BETWEEN GAS RATES                  | 1  | 0.600625 | 0.600625 |
| TEMP X G-RATE INTERACTION          | 1  | 0.765625 | 0.765625 |
|                                    | 3  | 34.14187 |          |

TABLE (K)

| PRESSURE X WATER-RATE ANOVA TABLE |    |          |          |
|-----------------------------------|----|----------|----------|
| SOURCE                            | df | SS       | MS       |
| BETWEEN PRESSURES                 | 1  | 4.305625 | 4.305625 |
| BETWEEN WATER RATES               | 1  | 0.105625 | 0.105625 |
| PRESS X W-RATE INTERACTION        | 1  | 0.005625 | 0.005625 |
|                                   | 3  | 4.416875 |          |

TABLE (L)

PRESSURE X GAS RATE ANOVA TABLE

| SOURCE                     | df | SS       | MS       |
|----------------------------|----|----------|----------|
| BETWEEN PRESSURES          | 1  | 4.305625 | 4.305625 |
| BETWEEN GAS RATES          | 1  | 0.600625 | 0.600625 |
| PRESS X G-RATE INTERACTION | 1  | 0.105625 | 0.105625 |
| -----                      |    |          |          |
|                            | 3  | 5.011875 |          |

TABLE (M)

WATER-RATE X GAS-RATE ANOVA TABLE

| SOURCE                      | df | SS       | MS       |
|-----------------------------|----|----------|----------|
| BETWEEN WATER RATES         | 1  | 0.105625 | 0.105625 |
| BETWEEN GAS RATES           | 1  | 0.600625 | 0.600625 |
| W-RATE X G-RATE INTERACTION | 1  | 0.330625 | 0.330625 |
| -----                       |    |          |          |
|                             | 3  | 1.036875 |          |

TABLE (N)

| SOURCE                    | df | SS        | MS       | F.VALUE  |
|---------------------------|----|-----------|----------|----------|
| BETWEEN TEMPERATURES      | 1  | 32.775625 | 32.77562 | 17.80679 |
| BETWEEN PRESSURES         | 1  | 4.305625  | 4.305625 | 2.339219 |
| BETWEEN WATER RATES       | 1  | 0.105625  | 0.105625 | 0.057385 |
| BETWEEN GAS RATES         | 1  | 0.600625  | 0.600625 | 0.326315 |
| T X P INTERACTION         | 1  | 0.390625  | 0.390625 |          |
| T X W INTERACTION         | 1  | 4.305625  | 4.305625 |          |
| T X G INTERACTION         | 1  | 0.765625  | 0.765625 |          |
| P X W INTERACTION         | 1  | 0.005625  | 0.005625 |          |
| P X G INTERACTION         | 1  | 0.105625  | 0.105625 |          |
| W X G INTERACTION         | 1  | 0.330625  | 0.330625 |          |
| HIGHER ORDER INTERACTIONS | 5  | 9.203125  | 1.840625 |          |
| -----                     |    |           |          |          |
|                           | 15 | 52.894375 |          |          |

F 0.05 [1/5] = 6.61

TABLE 5.4

SUMMARY TABLE  
EFFECT OF OPERATING CONDITIONS

| RUN # | TABLE # | TEMP °C | W RATE ML/H | G RATE L/H | PRESS PSIG | OIL  | GAS | ADDOVE | SAND MESH | SALT CONC G/L | D.R.E.I. RECOVERY % |
|-------|---------|---------|-------------|------------|------------|------|-----|--------|-----------|---------------|---------------------|
| 4-01  | A8      | 100     | 500         | 36         | 200        | PLCN | N2  | ---    | 55        | 5             | 4.4 57.7            |
| 4-02  | A9      | 134     | 1530        | 36         | 200        | PLCN | N2  | ---    | 55        | 5             | 5.8 73.1            |
| 4-03  | A10     | 125     | 530         | 177        | 200        | PLCN | N2  | ---    | 55        | 5             | 4.1 62.7            |
| 4-04  | A11     | 125     | 1530        | 177        | 200        | PLCN | N2  | ---    | 55        | 5             | 7.3 62.5            |
| 4-05  | A12     | 106     | 530         | 36         | 100        | PLCN | N2  | ---    | 55        | 5             | 4.1 62.8            |
| 4-06  | A13     | 105     | 1530        | 36         | 100        | PLCN | N2  | ---    | 55        | 5             | 4.2 59.3            |
| 4-07  | A14     | 109     | 530         | 177        | 100        | PLCN | N2  | ---    | 55        | 5             | 5.8 65.6            |
| 4-08  | A15     | 112     | 1530        | 177        | 100        | PLCN | N2  | ---    | 55        | 5             | 4.6 67.6            |
| 4-09  | A16     | 154     | 530         | 36         | 200        | PLCN | N2  | ---    | 55        | 5             | 10 57.9             |
| 4-10  | A17     | 154     | 1530        | 36         | 200        | PLCN | N2  | ---    | 55        | 5             | 7.3 61.6            |
| 4-11  | A18     | 134     | 530         | 177        | 200        | PLCN | N2  | ---    | 55        | 5             | 9.7 58.4            |
| 4-12  | A19     | 157     | 1530        | 177        | 200        | PLCN | N2  | ---    | 55        | 5             | 7.3 69.7            |
| 4-13  | A20     | 154     | 530         | 36         | 100        | PLCN | N2  | ---    | 55        | 5             | 7.5 64.8            |
| 4-14  | A21     | 154     | 1530        | 36         | 100        | PLCN | N2  | ---    | 55        | 5             | 6.9 61.5            |
| 4-15  | A22     | 154     | 530         | 177        | 100        | PLCN | N2  | ---    | 55        | 5             | 6.8 68.9            |
| 4-16  | A23     | 150     | 1530        | 177        | 100        | PLCN | N2  | ---    | 55        | 5             | 7.7 67.3            |

## 6. GAS/OIL/PERMEABILITY INTERACTIONS

### 6.1 Experimental Conditions and General Results

Oil displacement experiments to investigate gas, oil and permeability interactions on the Hot Water/Gas process are reported in this section. The variables examined in this part of the project were:-

1. Type of oil
2. Type of injection gas
3. Permeability of sand

Two heavy oils (Alberta's Pelican Lake oil and Saskatchewan Buffalo Coulee oil) were used. The gases used were nitrogen and carbon dioxide. For the sand cores, either 55 or 125 mesh Ottawa sand was homogeneously packed. Other operating conditions, i.e. temperature, pressure, water injection rate, gas injection rate, packing, saturation and injection procedures were kept constant from run to run throughout the entire set of experiments.

A 2<sup>3</sup> factorial design of experiments was followed to assess the interactions of these variables. A listing of the set of experimental conditions is given in Table 6.1.

The results of seven of the eight planned experiments are shown in Figures 6.1 to 6.28. Conditions of experiment 5-01 are identical to those of the previously reported Run 4-05; and therefore the run was not repeated. For each of the 7 experiments, the following characteristic curves are shown:-

- . Cumulative oil recovery
- . Cumulative water-oil ratio
- . Observed temperature profiles
- . History of observed pressure drop

Highlights of the results immediately observable from the experimental data are given in the following:-

- . The general trends observed with this last set of experiments are similar and consistent with those observed in the previous experiments, reported in Section 5.
- . CO<sub>2</sub>, as expected, shows generally a higher incremental oil recovery in comparison to nitrogen.
- . The effect of CO<sub>2</sub> interaction is more pronounced with the Pelican Lake oil, than with the Buffalo Coulee oil. Thus, in the latter case, the advantage of CO<sub>2</sub> over nitrogen is small.
- . The permeability of the sand core showed little effect on oil recovery and water-oil ratio.

TABLE 6.1  
OIL/GAS/PERMEABILITY INTERACTIONS  
EXPERIMENTAL CONDITIONS

| <u>Experiment</u> | <u>Oil</u>     | <u>Gas</u>      | <u>Sand</u> |
|-------------------|----------------|-----------------|-------------|
| 5-01              | Pelican Lake   | N <sub>2</sub>  | 55 mesh     |
| 5-02              | Pelican Lake   | CO <sub>2</sub> | 55 mesh     |
| 5-03              | Pelican Lake   | CO <sub>2</sub> | 125 mesh    |
| 5-04              | Pelican Lake   | N <sub>2</sub>  | 125 mesh    |
| 5-05              | Buffalo Coulee | N <sub>2</sub>  | 55 mesh     |
| 5-06              | Buffalo Coulee | CO <sub>2</sub> | 55 mesh     |
| 5-07              | Buffalo Coulee | CO <sub>2</sub> | 125 mesh    |
| 5-08              | Buffalo Coulee | N <sub>2</sub>  | 125 mesh    |

|                      |          |
|----------------------|----------|
| Temperature          | 100°C    |
| Back Pressure        | 100 psig |
| Water Injection Rate | 530 mL/h |
| Gas Injection Rate   | 36 L/h   |

## 6.2 Statistical Analysis of Oil/Gas/Permeability Interactions

Similar to the analysis of the relative effects of the operating variables (Section 5.2), the oil recovery enhancement index was used to compare the results of the last set of experiments. The index (OREI) was defined and calculated using exactly the same methodology followed in analyzing the previous set of results (Section 5.2). The values of OREI for Runs 5-01 to 5-08 are reported in Table 6.2. These values were used, like the previous set, as the characteristic parameters, on which the analysis of variance was based.

The present set followed a  $2^3$  factorial design. The three factors were type of oil, type of gas, and type of sand. Each factor is considered at two levels (Oil: Pelican or Buffalo Coulee, Gas:  $N_2$  or  $CO_2$  and Sand: 55 mesh or 125 mesh). The analysis of variance is given in Table 6.3 (A through H). Standard ANOVA calculations may be observed in the tables. It is clear from the analysis that only the gas effect is statistically significant at the 95% confidence level. This is in support of the observation that higher oil recoveries were associated with  $CO_2$  injection. This in turn suggests that such beneficial effects as viscosity reduction and solution gas drive must be playing a role in the process.

It is instructive to compare the OREI values calculated for this set of experiments with those calculated in the previous set (Section 5). One immediately observes that the OREI values associated with  $CO_2$  injection are significantly higher than those connected with  $N_2$ . This is a manifestation of the higher oil recoveries and recovery rates resulting from  $CO_2$  injection.

An interesting observation which may be drawn from the statistical analysis of the data is that the recoveries of the two oils were comparable in spite of their difference in viscosity. This may be explained by the fact that although the difference in the viscosity of the two oils is large at room temperature, the differences become smaller at higher temperatures (Table 1.1).

An overall summary table (Table 6.4) of the conditions and results of this series of runs is given after the statistical analysis tables.

FIGURE 6.3

TEMPERATURE HISTORY

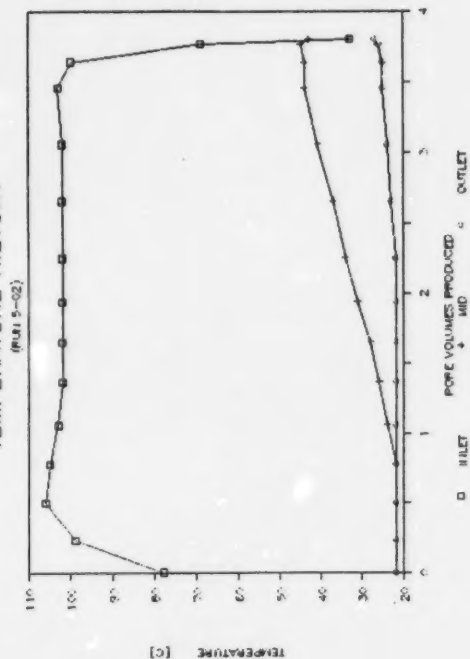


FIGURE 6.4

PRESSURE DROP HISTORY

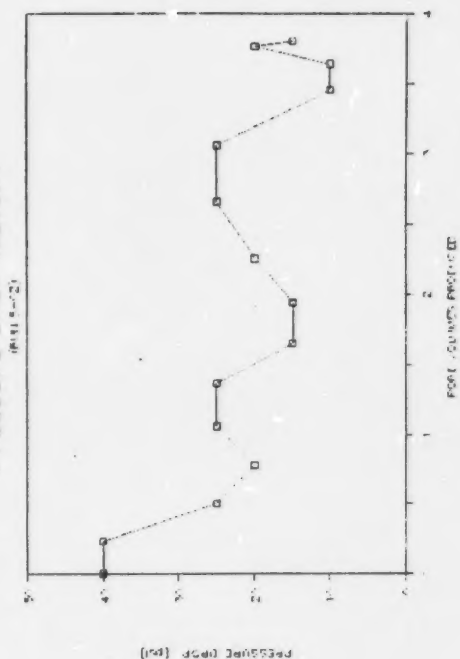


FIGURE 6.1

CUMULATIVE OIL RECOVERY

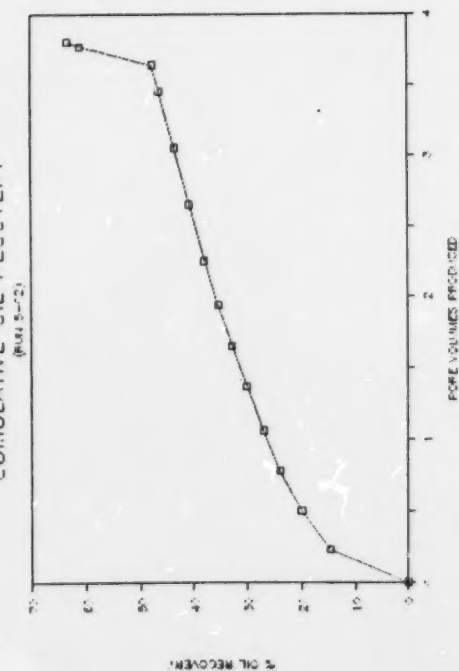
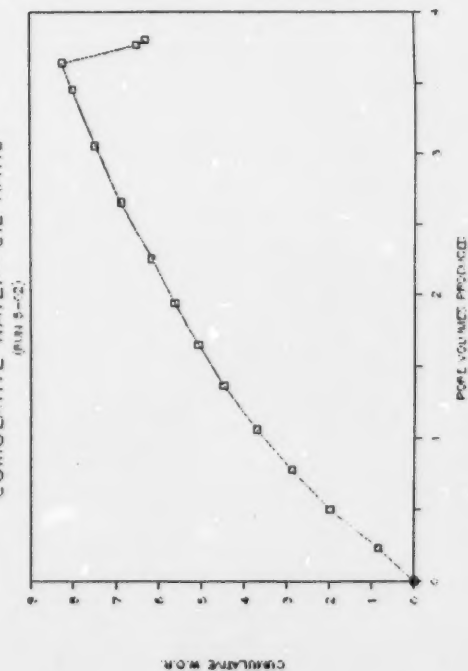


FIGURE 6.2

CUMULATIVE WATER-OIL RATIO



(TABLE A-25)

FIGURE 6.7

# TEMPERATURE HISTORY

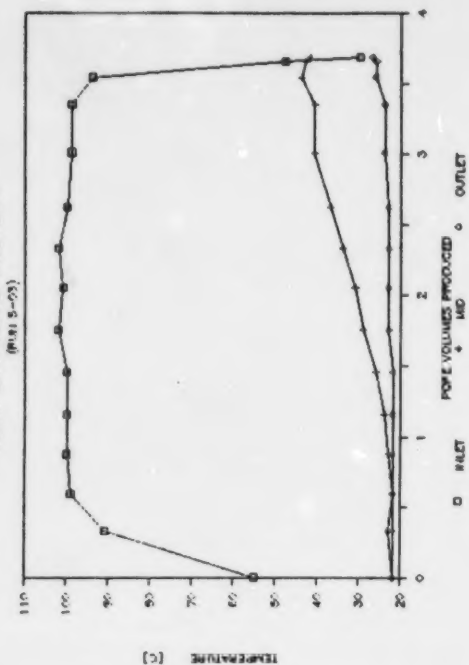


FIGURE 6.8

# PRESSURE DROP HISTORY

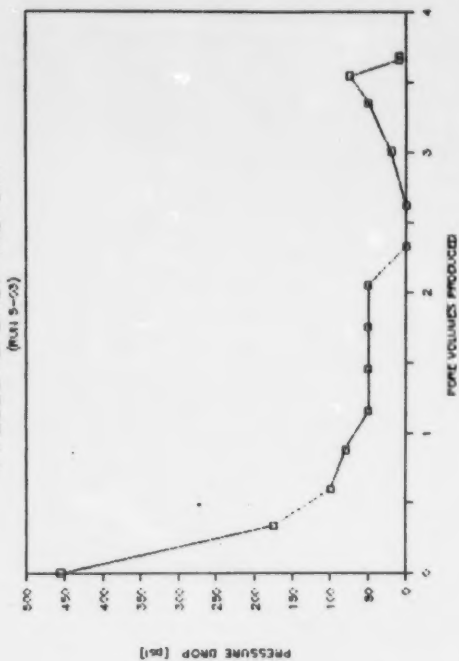


FIGURE 6.5

# CUMULATIVE OIL RECOVERY

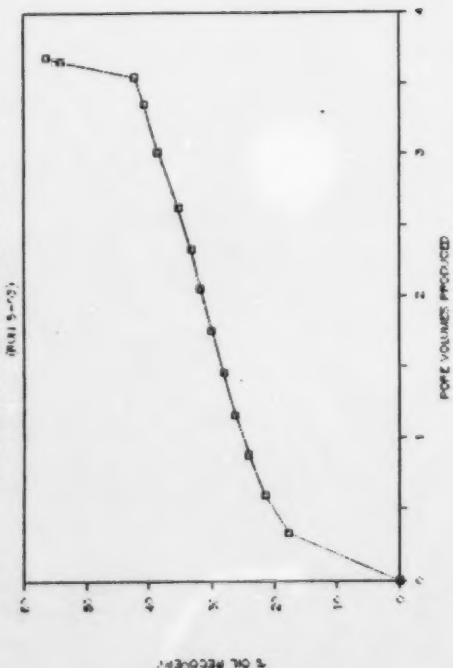
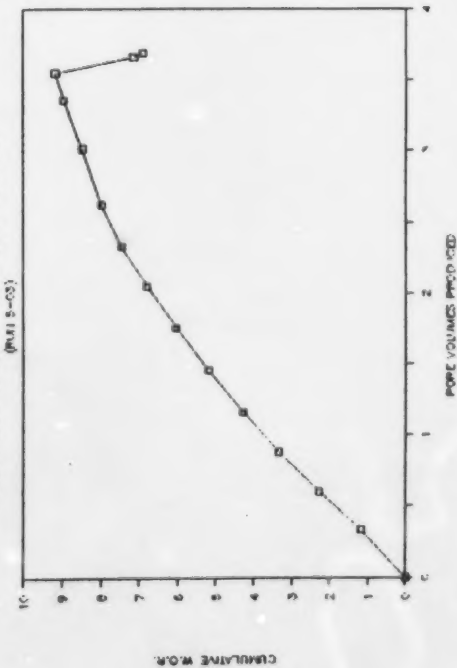


FIGURE 6.6

# CUMULATIVE WATER-OIL RATIO



(TABLE A-26)

FIGURE 6.11

TEMPERATURE HISTORY

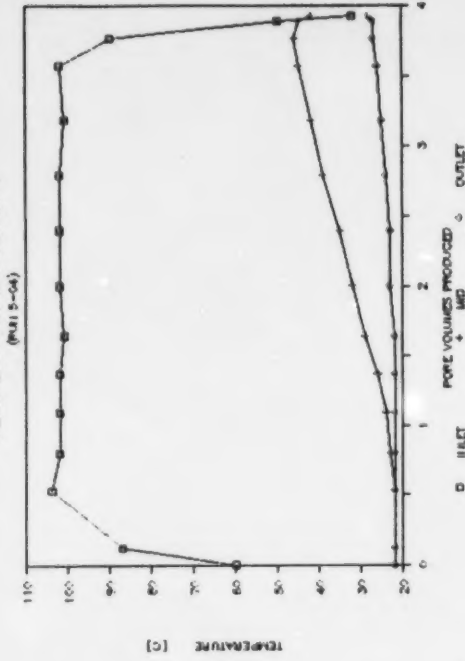


FIGURE 6.12

PRESSURE DROP HISTORY

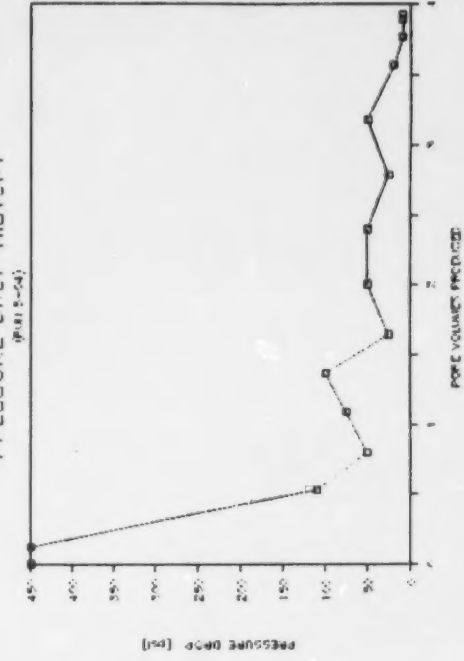


FIGURE 6.9

CUMULATIVE OIL RECOVERY

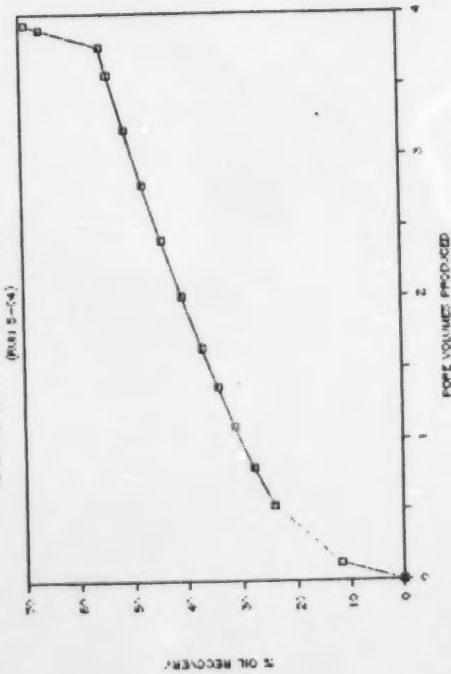


FIGURE 6.10

CUMULATIVE WATER-OIL RATIO

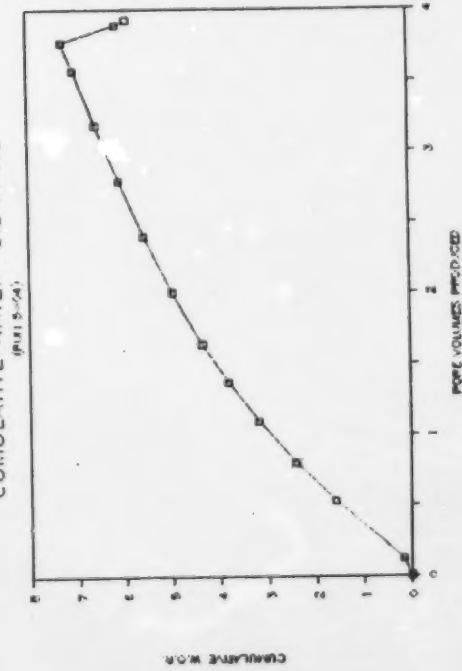


FIGURE 6.13

CUMULATIVE OIL RECOVERY

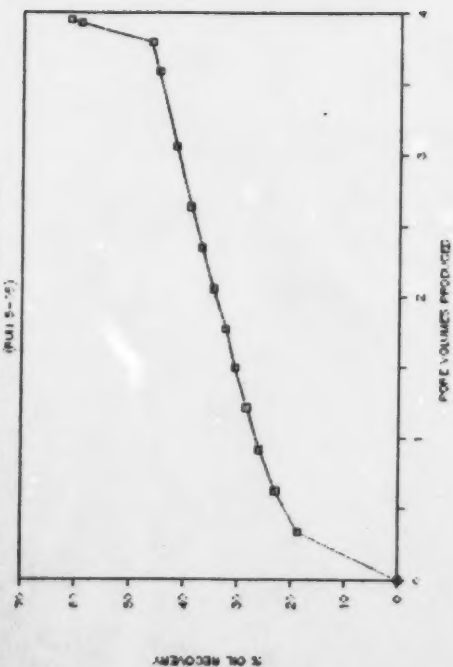


FIGURE 6.15

TEMPERATURE HISTORY

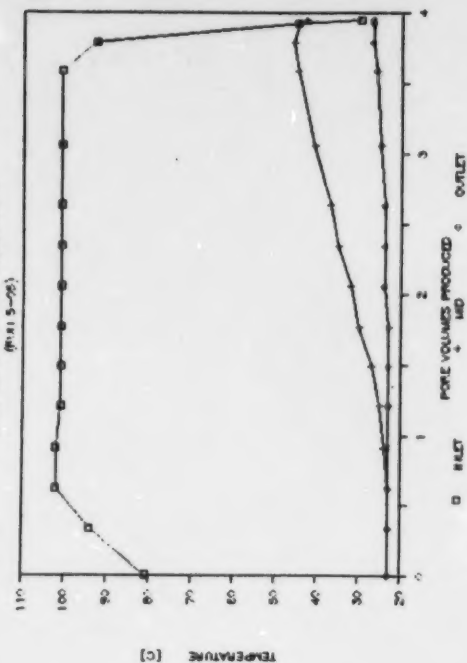


FIGURE 6.14

CUMULATIVE WATER-OIL RATIO

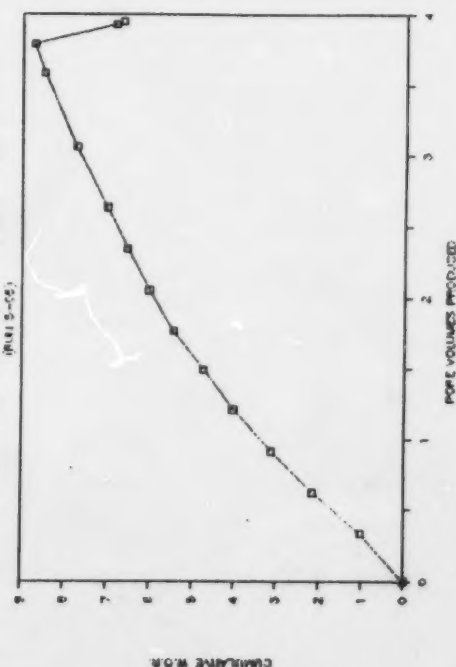
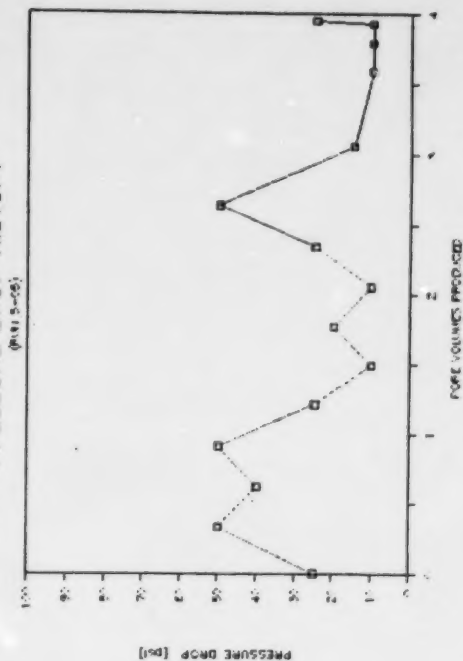


FIGURE 6.16

PRESSURE DROP HISTORY



(TABLE A-28)

FIGURE 6.17  
CUMULATIVE OIL RECOVERY  
(Plot 5-56)

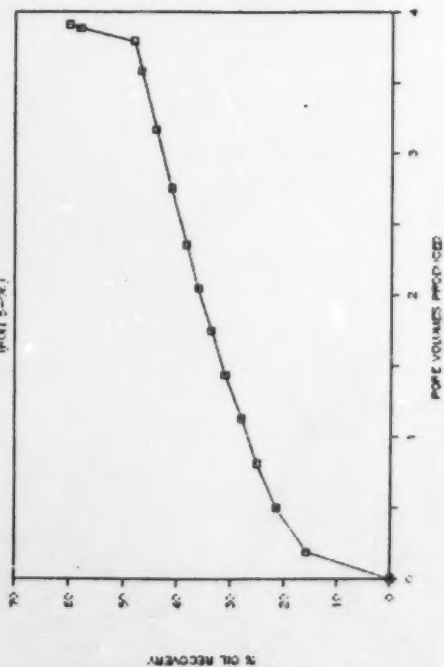


FIGURE 6.19  
TEMPERATURE HISTORY  
(Plot 5-56)

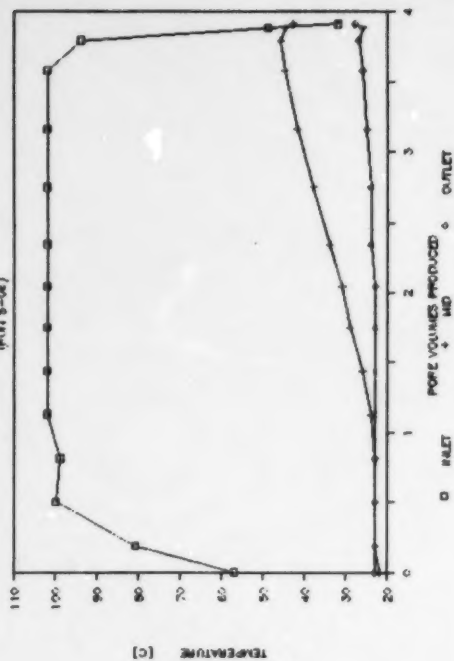


FIGURE 6.18  
CUMULATIVE WATER-OIL RATIO  
(Plot 5-56)

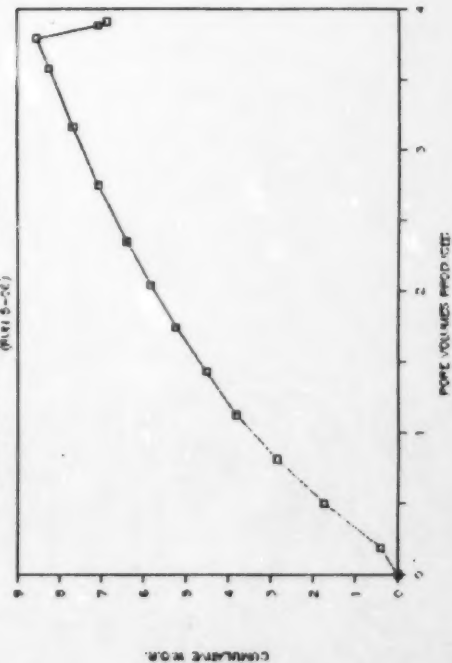


FIGURE 6.20  
PRESSURE DROP HISTORY  
(Plot 5-56)

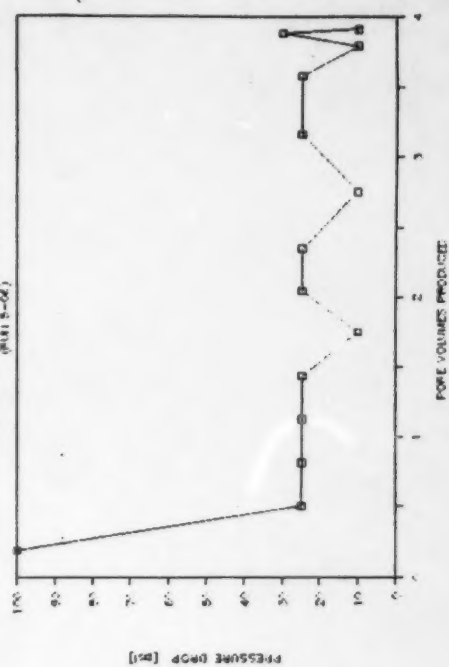


FIGURE 6.21  
CUMULATIVE OIL RECOVERY  
(PALL 5-07)

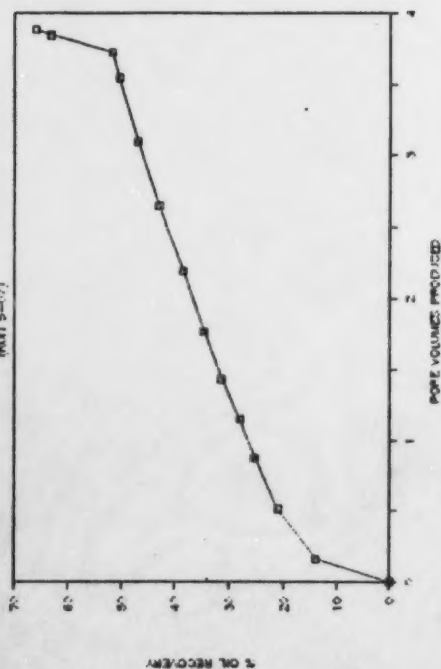


FIGURE 6.23  
TEMPERATURE HISTORY  
(PALL 5-07)

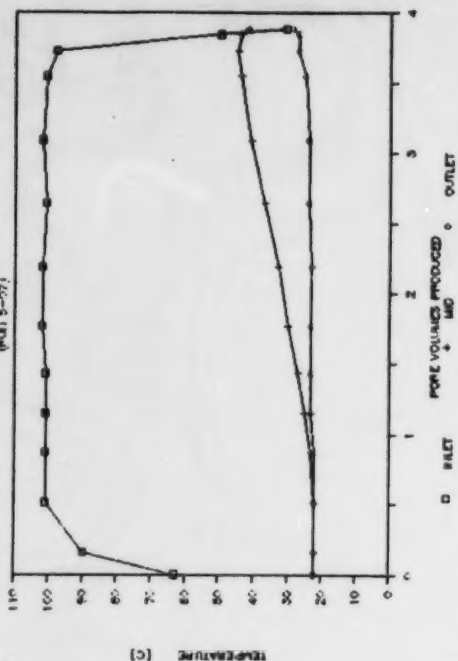


FIGURE 6.22  
CUMULATIVE WATER-OIL RATIO  
(PALL 5-07)

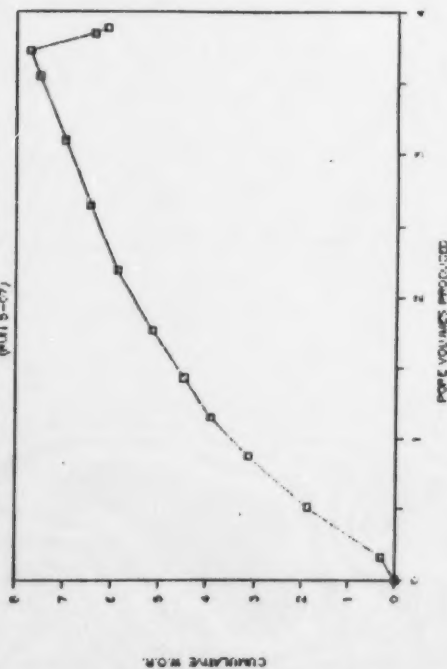
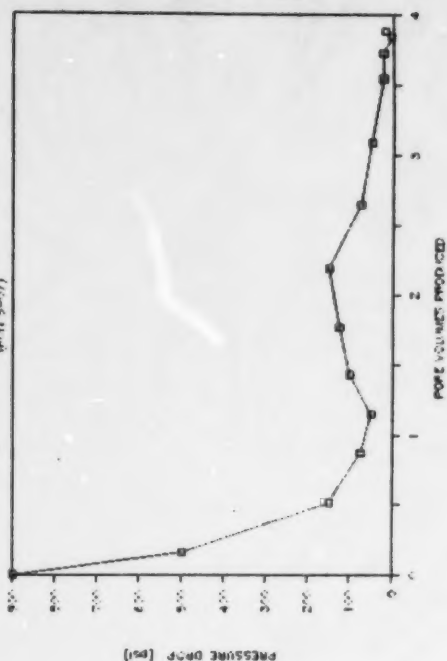


FIGURE 6.24  
PRESSURE DROP HISTORY  
(PALL 5-07)



(TABLE A-30)

FIGURE 6.27

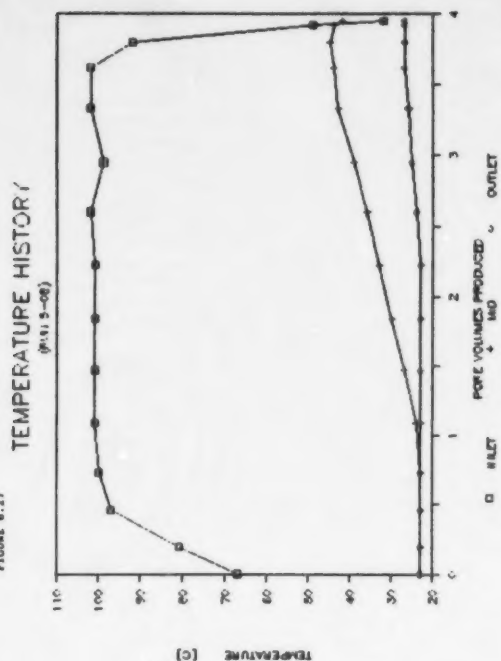


FIGURE 6.28

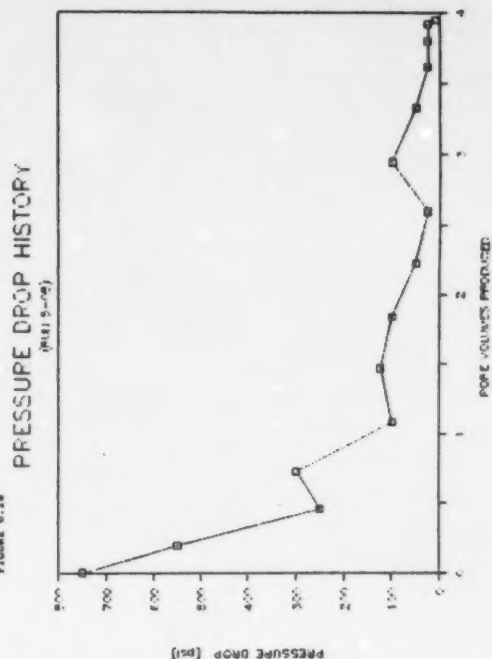


FIGURE 6.25

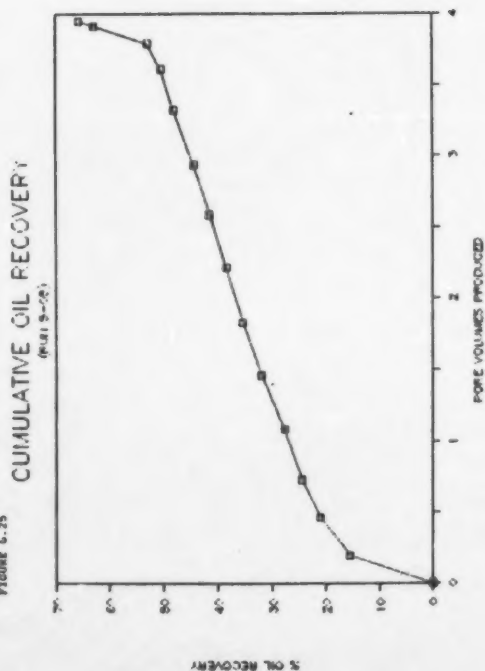
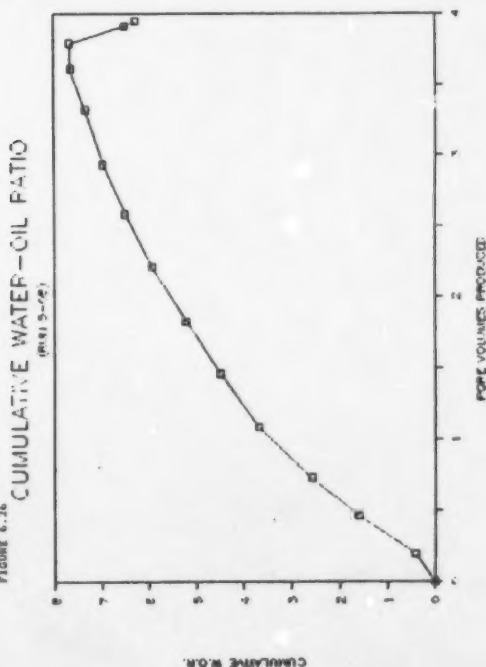


FIGURE 6.26



(TABLE A-31)

TABLE 6.2

OIL/GAS/PERMEABILITY INTERACTIONS/  
OIL RECOVERY ENHANCEMENT INDEX

| <u>EXPERIMENT</u> | <u>OREI</u> |
|-------------------|-------------|
| 5-01              | 4.1         |
| 5-02              | 13.6        |
| 5-03              | 13.6        |
| 5-04              | 5.4         |
| 5-05              | 7.1         |
| 5-06              | 15.1        |
| 5-07              | 10.9        |
| 5-08              | 9.2         |

## ANALYSIS OF VARIANCE TABLES

OIL - GAS - PERMEABILITY INTERACTIONS  
\*\*\*\*\*

TABLE (A)

ANOVA TABLE  
-----

|             |    | O1   | O2   |
|-------------|----|------|------|
| G1          | S1 | 4.1  | 7.1  |
| G1          | S2 | 5.4  | 9.2  |
| G2          | S1 | 13.6 | 15.1 |
| G2          | S2 | 13.6 | 10.9 |
| SUM COLUMNS |    | 36.7 | 42.3 |

|                   |     |      |     |      |
|-------------------|-----|------|-----|------|
| SUM OILS:         | O1= | 36.7 | O2= | 42.3 |
| SUM GAS:          | G1= | 25.8 | G2= | 53.2 |
| SUM PERMEABILITY: | S1= | 39.9 | S2= | 39.1 |

|                   |         |
|-------------------|---------|
| GRAND SUM         | 79      |
| CORRECTION        | 780.125 |
| TOTAL VARIANCE SS | 117.635 |

TABLE (B)

## INTERACTION TABLE

## OIL X GAS

## GAS

## SUM OIL

| OIL      | N2   | CO2  |      |
|----------|------|------|------|
| PELICAN  | 9.5  | 27.2 | 36.7 |
| B.COULEE | 16.3 | 26   | 42.3 |
| SUM GAS  | 25.8 | 53.2 |      |

|            |         |
|------------|---------|
| SS [TOT] = | 105.765 |
| SS [OIL] = | 3.92    |
| SS [GAS] = | 93.845  |

TABLE (C)

## INTERACTION TABLE

OIL X PERMEABILITY  
PERMEABILITY

## SUM OIL

| OIL              | 55-MESH | 125-MESH |      |
|------------------|---------|----------|------|
| PELICAN          | 17.7    | 19       | 36.7 |
| B.COULEE         | 22.2    | 20.1     | 42.3 |
| SUM PERMEABILITY | 39.9    | 39.1     |      |

|             |       |
|-------------|-------|
| SS [TOT] =  | 5.445 |
| SS [OIL] =  | 3.92  |
| SS [PERM] = | 0.08  |

TABLE (D)

## INTERACTION TABLE

GAS X PERMEABILITY  
PERMEABILITY

## SUM GAS

| GAS              | 55-MESH | 125-MESH |      |
|------------------|---------|----------|------|
| N2               | 11.2    | 14.6     | 25.8 |
| CO2              | 28.7    | 24.5     | 53.2 |
| SUM PERMEABILITY | 39.9    | 39.1     |      |

|             |         |
|-------------|---------|
| SS [TOT] =  | 101.145 |
| SS [GAS] =  | 93.845  |
| SS [PERM] = | 0.08    |

TABLE (E)  
OIL X GAS ANOVA TABLE

| SOURCE                | df | SS      | MS     |
|-----------------------|----|---------|--------|
| BETWEEN OILS          | 1  | 3.92    | 3.92   |
| BETWEEN GASES         | 1  | 93.845  | 93.845 |
| OIL X GAS INTERACTION | 1  | 8       | 8      |
| <hr/>                 |    |         |        |
|                       | 3  | 105.765 |        |

TABLE (F)  
OIL X PERMEABILITY ANOVA TABLE

| SOURCE                      | df | SS    | MS    |
|-----------------------------|----|-------|-------|
| BETWEEN OILS                | 1  | 3.92  | 3.92  |
| BETWEEN PERMEABILITIES      | 1  | 0.08  | 0.08  |
| OIL X PERMEABILITY INTERACT | 1  | 1.445 | 1.445 |
| <hr/>                       |    |       |       |
|                             | 3  | 5.445 |       |

TABLE (G)  
GAS X PERMEABILITY ANOVA TABLE

| SOURCE                      | df | SS      | MS     |
|-----------------------------|----|---------|--------|
| BETWEEN GASES               | 1  | 93.845  | 93.845 |
| BETWEEN PERMEABILITIES      | 1  | 0.08    | 0.08   |
| GAS X PERMEABILITY INTERACT | 1  | 7.22    | 7.22   |
| <hr/>                       |    |         |        |
|                             | 3  | 101.145 |        |

TABLE (H)

| SOURCE                    | df | SS     | MS     | F.VALUE  |
|---------------------------|----|--------|--------|----------|
| BETWEEN OILS              | 1  | 3.92   | 3.92   | 0.792319 |
| BETWEEN GASES             | 1  | 93.845 | 93.845 | 18.96816 |
| BETWEEN PERMEABILITIES    | 1  | 0.08   | 0.08   | 0.016169 |
| O X G INTERACTION         | 1  | 8      | 8      |          |
| O X S INTERACTION         | 1  | 1.445  | 1.445  |          |
| G X S INTERACTION         | 1  | 7.22   | 7.22   |          |
| HIGHER ORDER INTERACTIONS | 1  | 3.125  | 3.125  |          |

-----  
117.635 19.79  
ESTIMATE OF ERROR VARIANCE 4.9475

F 0.05 [1/4] = 7.71

TABLE 6.4

SUMMARY TABLE  
GAS / OIL / PERMEABILITY INTERACTIONS

| RUN # | TABLE # | TEMP C | W RATE ML/H | G RATE L/H | PRESS PSIG | OIL     | GAS | ADDOVE | SAND MESH | SALT CONC G/L | O.R.E.I. RECOVERY % |
|-------|---------|--------|-------------|------------|------------|---------|-----|--------|-----------|---------------|---------------------|
| 5-01  | A24     | 106    | 530         | 36         | 100        | PLCN    | N2  | ---    | 55        | 5             | 4.1 62.8            |
| 5-02  | A25     | 103    | 530         | 36         | 100        | PLCN    | C02 | ---    | 55        | 5             | 13.6 63.3           |
| 5-03  | A26     | 102    | 530         | 36         | 100        | PLCN    | C02 | ---    | 125       | 5             | 13.6 56.5           |
| 5-04  | A27     | 102    | 530         | 36         | 100        | PLCN    | C02 | ---    | 125       | 5             | 5.4 69.2            |
| 5-05  | A28     | 102    | 530         | 36         | 100        | B.COLEE | N2  | ---    | 55        | 5             | 7.1 61.2            |
| 5-06  | A29     | 102    | 530         | 36         | 100        | B.COLEE | N2  | ---    | 55        | 5             | 15.1 60.1           |
| 5-07  | A30     | 102    | 530         | 36         | 100        | B.COLEE | C02 | ---    | 125       | 5             | 10.9 66.1           |
| 5-08  | A31     | 102    | 530         | 36         | 100        | C.COLEE | N2  | ---    | 125       | 5             | 9.2 65.6            |

## 7. EFFECT OF ADDITIVES

### 7.1 **Experimental Conditions and General Discussion**

In this section, the benefits of interfacial additives in oil recovery, using the hot water/gas drive are examined. A set of 16 displacement experiments have been carried out, using two different additives:-

1. Sodium hydroxide
2. Petroleum sulfonate additive, TRS 410

Each of the two additives was used at two different concentrations with each of two oils (Pelican Lake crude and Buffalo Coulee crude), for a total of 8 experiments. In each displacement experiment, the additive solution was injected as a slug (0.5 PV) after hot water injection. The set of 8 experiments was then repeated at a different salt concentration of the connate water.

The operating conditions, i.e. temperature, pressure, water injection rate, gas injection rate, packing, sand mesh size, saturation and injection procedures were kept constant from run to run throughout the entire set of experiments. A 2<sup>4</sup> factorial design of experiments was followed to assess the interactions of the four noted variables:-

1. Type of oil
2. Type of additive
3. Concentration of additive
4. Concentration of salt in formation water.

A listing of the experimental conditions is given in Table 7.1.

The results of the 16 experiments are shown in Figures 7.1 to 7.63. As usual, the following characteristic curves are shown:-

- . Cumulative oil recovery
- . Cumulative water-oil ratio
- . Observed temperature profiles
- . History of observed pressure drop

Highlights and general observations with regard to the experimental results are given in the following:-

- . The general trends observed with this set of experiments are similar and consistent with the previously observed general trends, Sections 5 and 6.
- . Initial hot water injection (4 PV) accounts for about 45% of oil recovery in all 16 displacement experiments.
- . Injection of 0.5 PV of sodium hydroxide solution followed by nitrogen, results in as much as 70% increase, over initial recovery by hot water, in the recovery of Pelican Lake oil.

- Enhancement of oil recovery was also noticeable, but less pronounced, in case of the Buffalo Coulee oil.
- Injection of sodium hydroxide solutions was generally more favourable, in terms of oil recovery, than the petroleum sulfonate IRS 410.
- Within the examined ranges, additive concentration had a small effect on oil recovery. This observation is applicable to both NaOH and TRS 410 solutions.
- Oil recoveries at the higher salt concentration, of the connate water, are somewhat lower than at the lower concentration. This indicates relatively unfavourable interactions of the additives with the connate water at the higher salt concentration. Such unfavourable interactions can be explained by higher interfacial tensions (in case of NaOH) and defoaming characteristics of salt (in case of TRS 410). The latter effects are well documented in the literature (15,16).
- Comparing oil recoveries of this set of experiments, with the previous two sets of experiments, shows a definite advantage to employing interfacial additives (particularly NaOH) in the hot water/gas drive process.

TABLE 7.1

EFFECT OF INTERFACIAL ADDITIVES  
EXPERIMENTAL CONDITIONS

| Experiment | Oil            | Additive | Additive<br>Concentration<br>g/L | Salt<br>Concentration<br>g/L |
|------------|----------------|----------|----------------------------------|------------------------------|
| 6-01       | Pelican Lake   | NaOH     | 1.0                              | 1.0                          |
| 6-02       | Pelican Lake   | NaOH     | 5.0                              | 1.0                          |
| 6-03       | Pelican Lake   | TRS 410  | 1.0                              | 1.0                          |
| 6-04       | Pelican Lake   | TRS 410  | 3.0                              | 1.0                          |
| 6-05       | Buffalo Coulee | NaOH     | 1.0                              | 1.0                          |
| 6-06       | Buffalo Coulee | NaOH     | 5.0                              | 1.0                          |
| 6-07       | Buffalo Coulee | TRS 410  | 1.0                              | 1.0                          |
| 6-08       | Buffalo Coulee | TRS 410  | 3.0                              | 1.0                          |
| 6-09       | Pelican Lake   | NaOH     | 1.0                              | 5.0                          |
| 6-10       | Pelican Lake   | TRS 410  | 1.0                              | 5.0                          |
| 6-11       | Buffalo Coulee | NaOH     | 1.0                              | 5.0                          |
| 6-12       | Buffalo Coulee | TRS 410  | 1.0                              | 5.0                          |
| 6-13       | Buffalo Coulee | TRS 410  | 3.0                              | 5.0                          |
| 6-14       | Buffalo Coulee | NaOH     | 5.0                              | 5.0                          |
| 6-15       | Pelican Lake   | NaOH     | 5.0                              | 5.0                          |
| 6-16       | Pelican Lake   | TRS 410  | 3.0                              | 5.0                          |

|                         |          |
|-------------------------|----------|
| Temperature             | 100°C    |
| Back Pressure           | 100 psig |
| Water Injection Rate    | 530 mL/h |
| Gas Injection Rate      | 36 L/h   |
| Volume of Additive Slug | 0.5 PV   |

## 7.2 Statistical Analysis of Additive/Salt/Oil Interactions

Similar to the statistical analysis detailed in Sections 5.2 and 6.2, the OREI values were calculated for this last set of experiments. The line segment used to calculate the oil recovery rate before gas injection, however, was somewhat different from the previous calculation (Section 5 and Section 6). In the present case, the segment covered and extended on the curve below additive injection. Therefore, a direct comparison with the previous OREI values is not meaningful. The OREI values are listed in Table 7.2. Analysis of variance was again carried out on the basis of the OREI values.

The main effects considered in the analysis of variance were the type of oil (Pelican Lake or Buffalo Coulee), type of additive (NaOH or TRS 410), concentration of additive (high or low), and the connate water salt concentration (1.0 or 5.0 g/L). It may be noted that the high additive concentrations were different (3.0 g/L in case of TRS 410 and 5.0 g/L in case of NaOH). These concentrations were selected based on previous experience with these additives (15,16).

The fact that the additive concentrations were different, at their high level, does not affect the analysis of variance. The analysis was only concerned with using each additive at two different levels of concentration.

Table 7.3 (A through N) shows standard analysis of variance of this  $2^4$  factorial experiment. The analysis shows that there is a statistically significant difference between the additives, supporting the observation that NaOH resulted generally in higher oil recovery. The effect of connate water salt concentration is also nearly significant, in evidence of the relatively unfavourable interactions (with additives) of high salt concentration.

An overall summary table (Table 7-4) highlighting the results of additive/salt/oil interactions is presented after the statistical analysis tables.

FIGURE 7.3

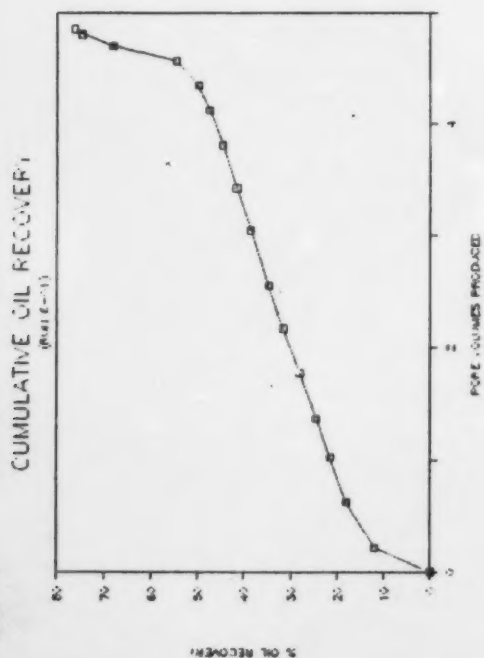


FIGURE 7.3

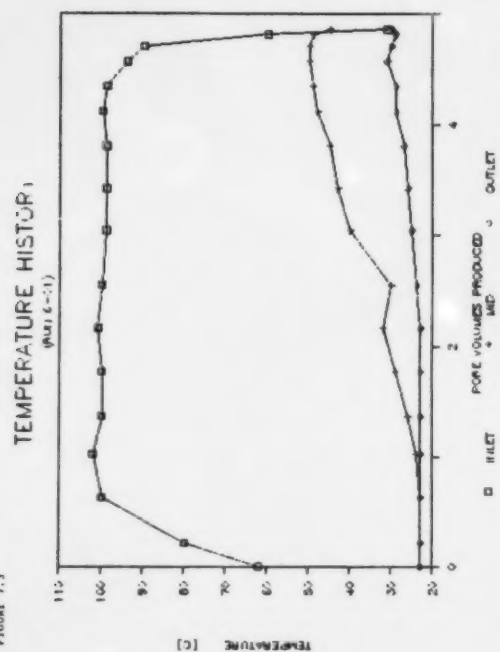


FIGURE 7.4

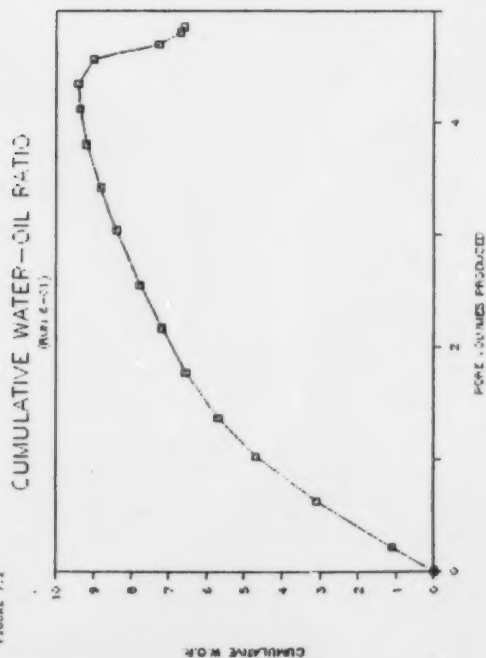
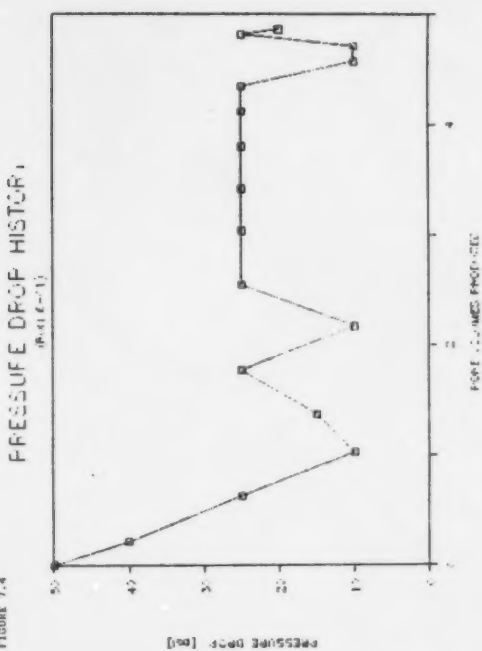


FIGURE 7.4



(TABLE A-32)

FIGURE 7.5  
CUMULATIVE OIL RECOVERY  
(PULL 6-02)

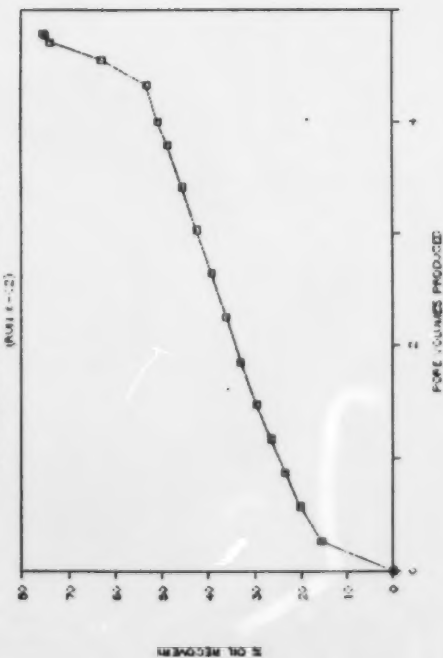


FIGURE 7.7  
TEMPERATURE HISTOR  
(PULL 6-02)

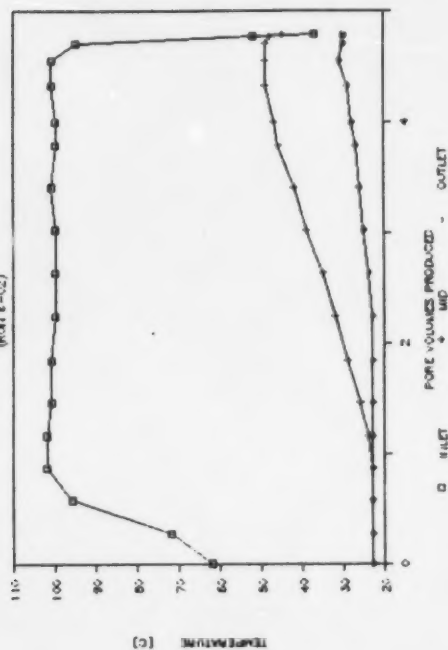


FIGURE 7.6  
CUMULATIVE WATER-OIL RATIO  
(PULL 6-02)

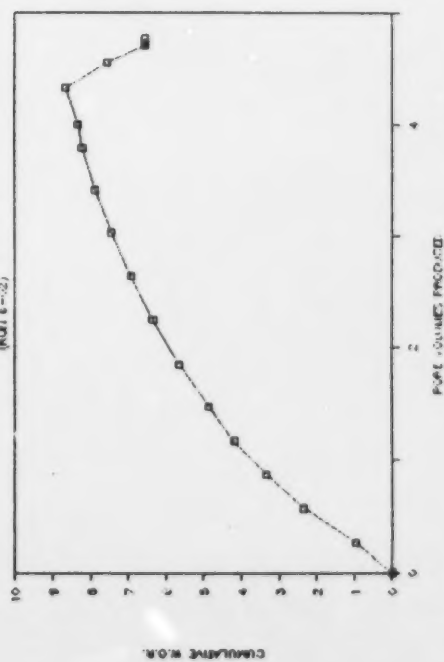


FIGURE 7.8  
PRESSURE DROP HISTOR  
(PULL 6-02)

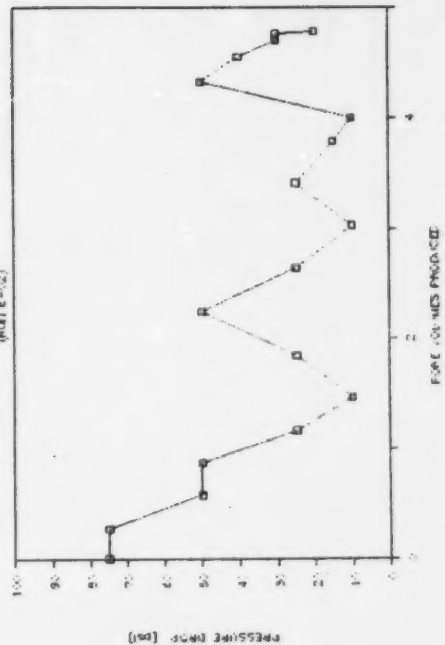


TABLE A-33)

FIGURE 7.9

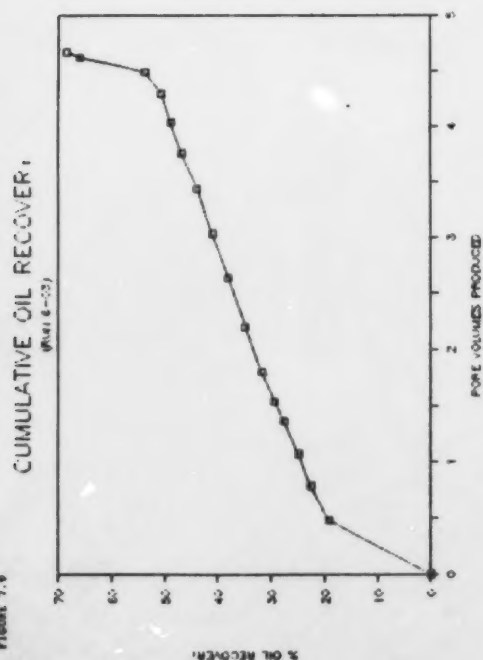


FIGURE 7.11

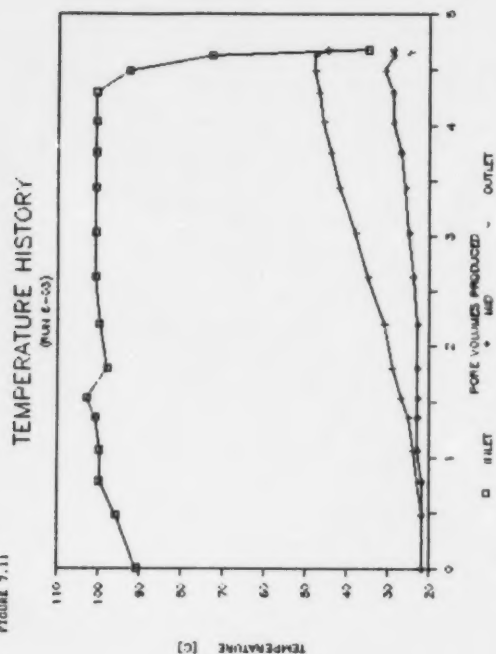


FIGURE 7.10

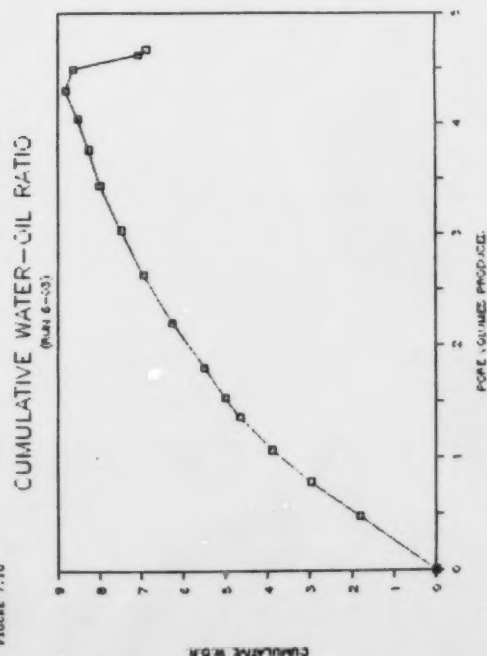
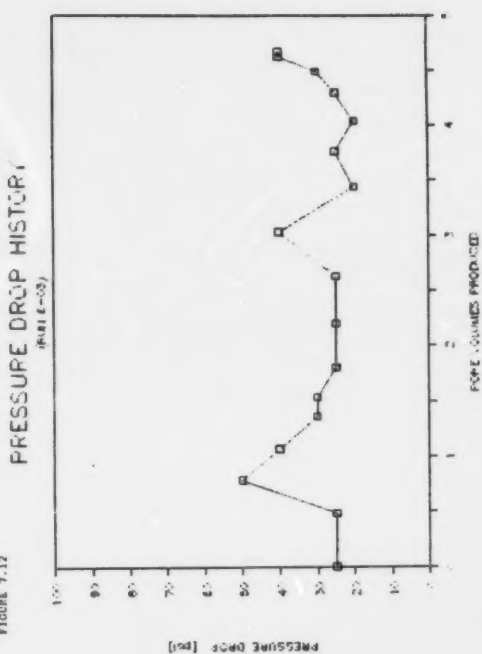


FIGURE 7.12



(TABLE A-34)

FIGURE 7.13  
(PVT 6-54)

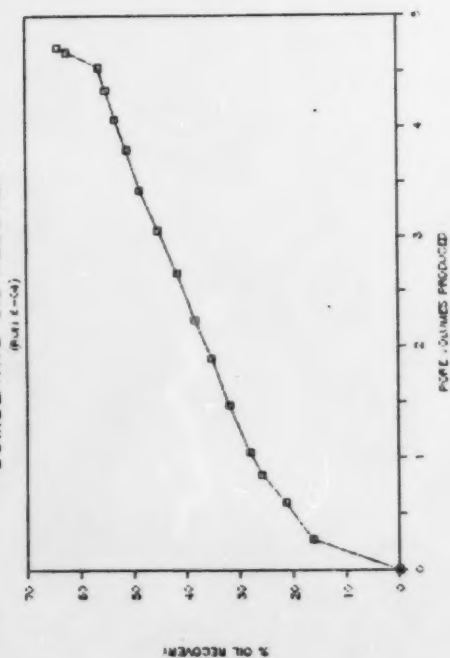


FIGURE 7.15

TEMPERATURE HISTORY  
(PVT 6-54)

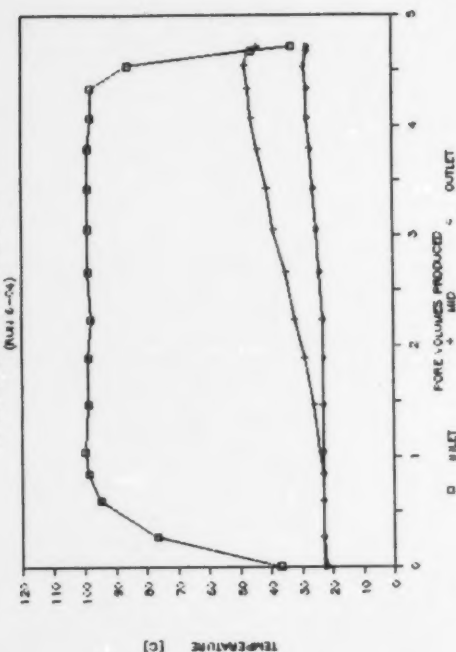


FIGURE 7.14

CUMULATIVE WATER-OIL RATIO  
(PVT 6-54)

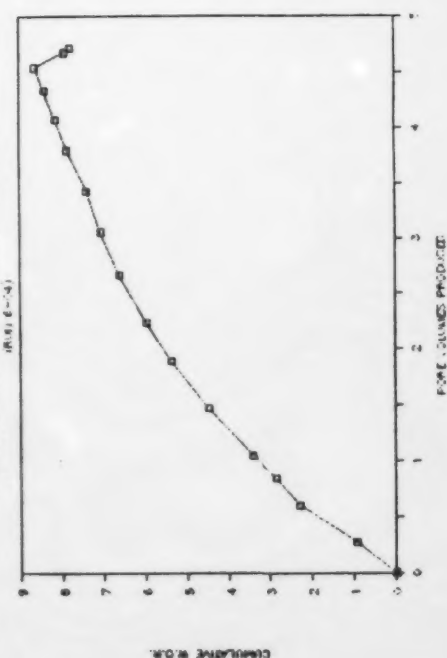


FIGURE 7.16

PRESSURE DROP HISTORY  
(PVT 6-54)

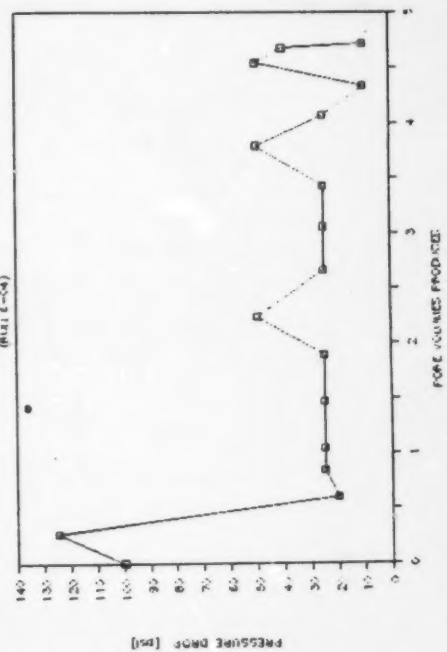


FIGURE 7.17

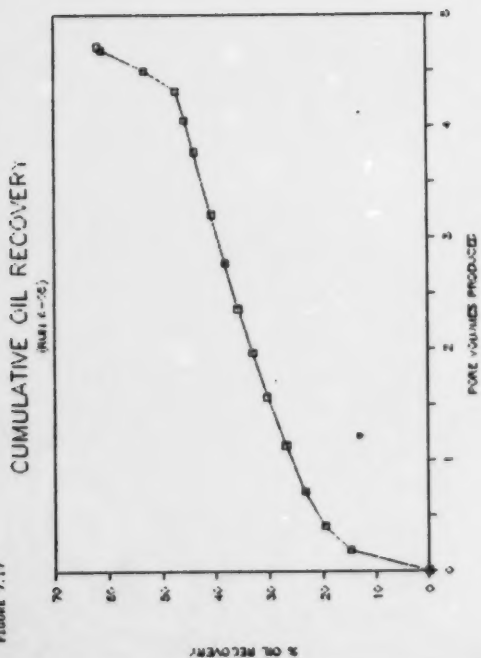


FIGURE 7.19

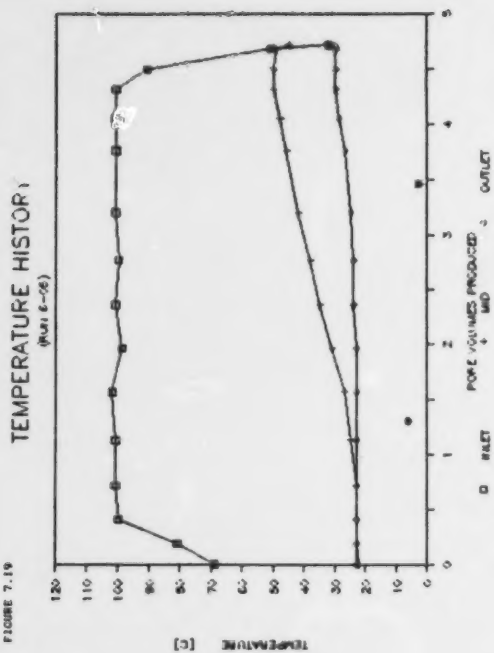


FIGURE 7.18

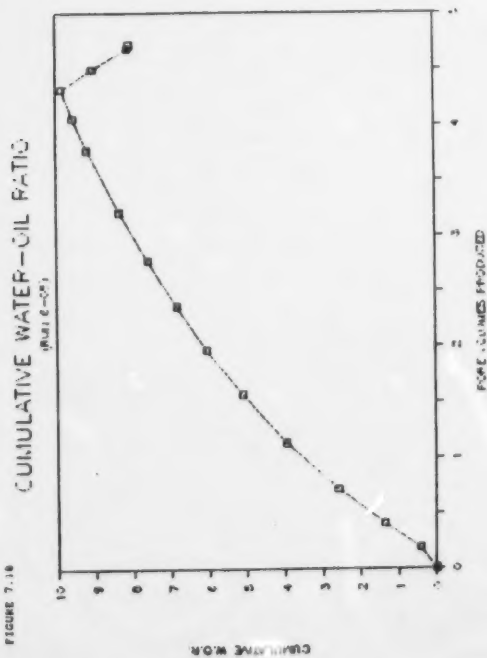
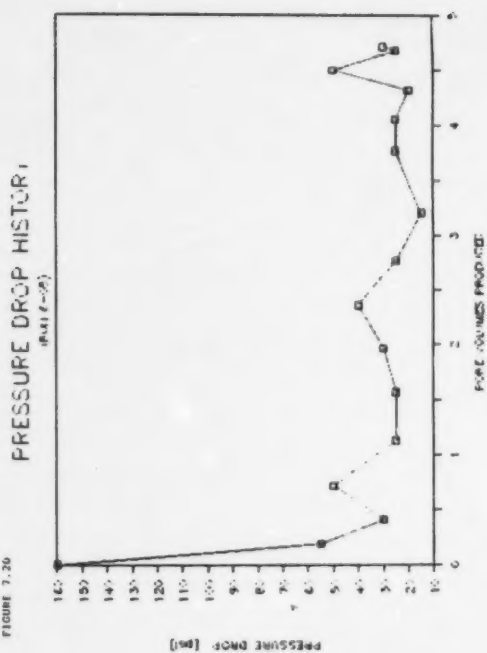


FIGURE 7.20



(TABLE A-36)

FIGURE 7.23  
TEMPERATURE HISTORY  
(Run 6-54)

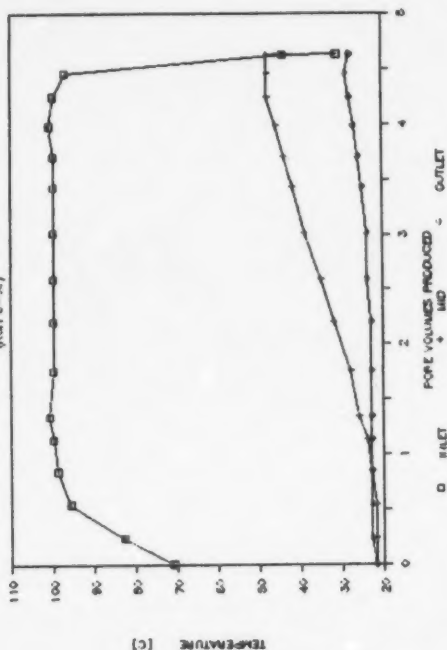


FIGURE 7.24  
PRESSURE DROP HISTORY  
(Run 6-54)

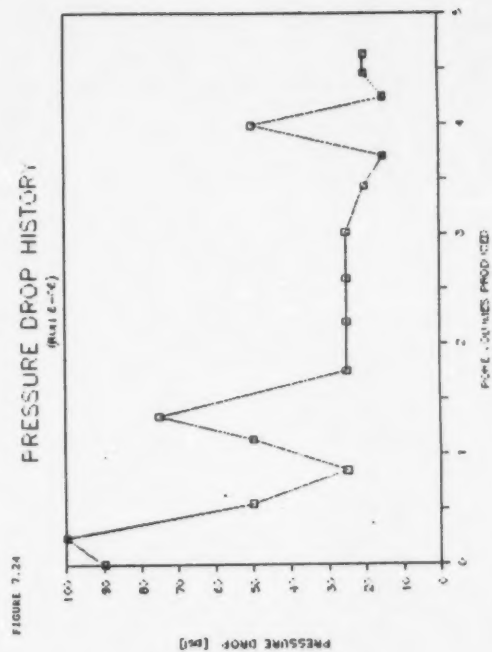


FIGURE 7.21  
CUMULATIVE OIL RECOVERY  
(Run 6-54)

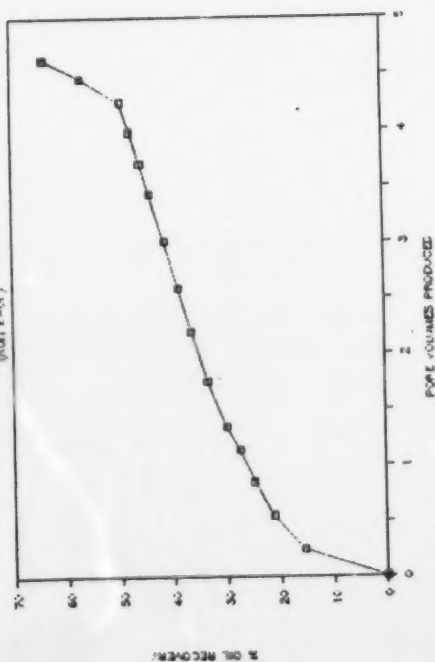
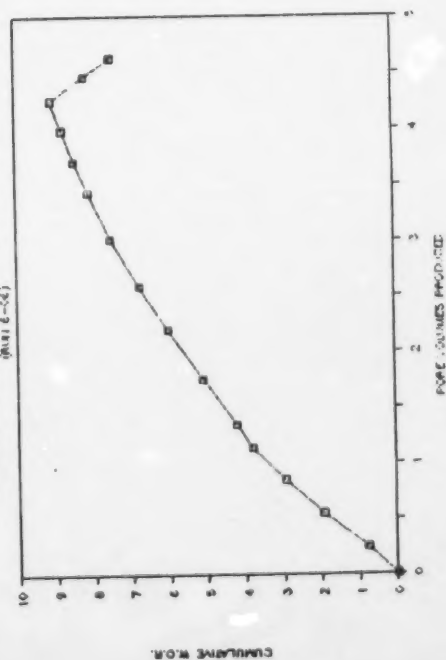


FIGURE 7.22  
CUMULATIVE WATER-OIL RATIO  
(Run 6-54)



(TABLE A-37)

FIGURE 7.25

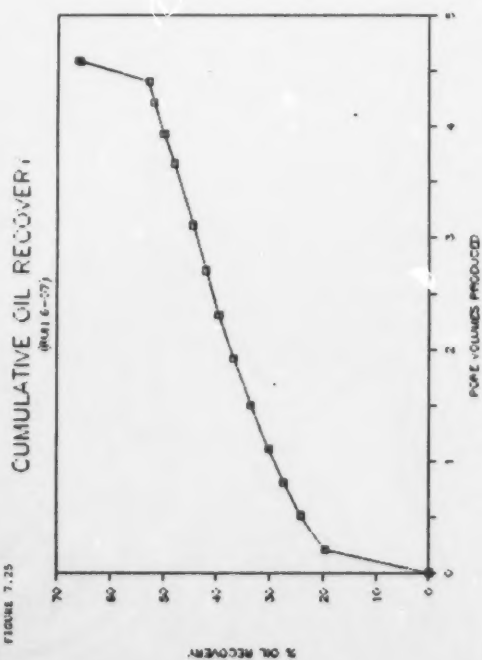


FIGURE 7.27

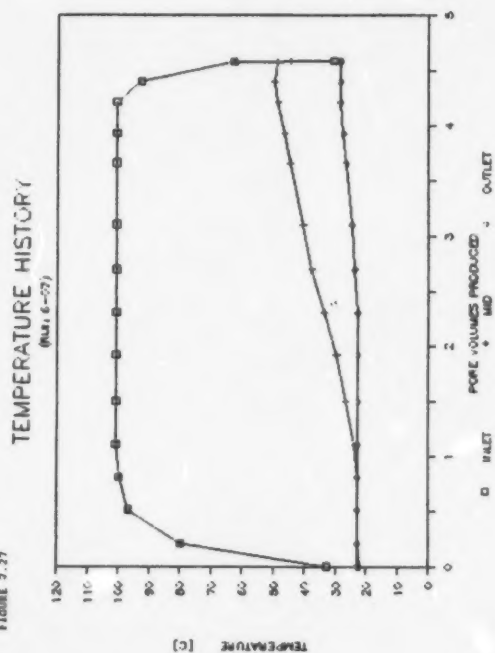


FIGURE 7.26

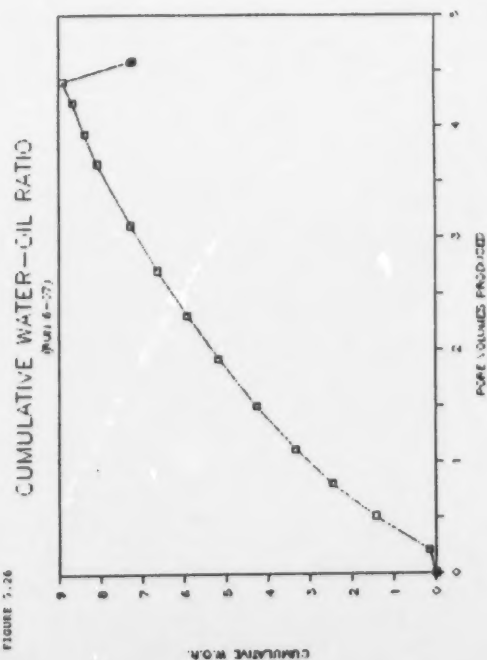
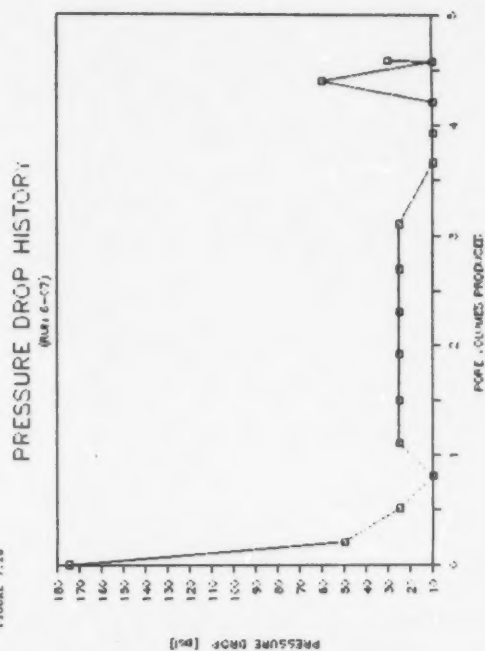


FIGURE 7.28



(TABLE A-38)

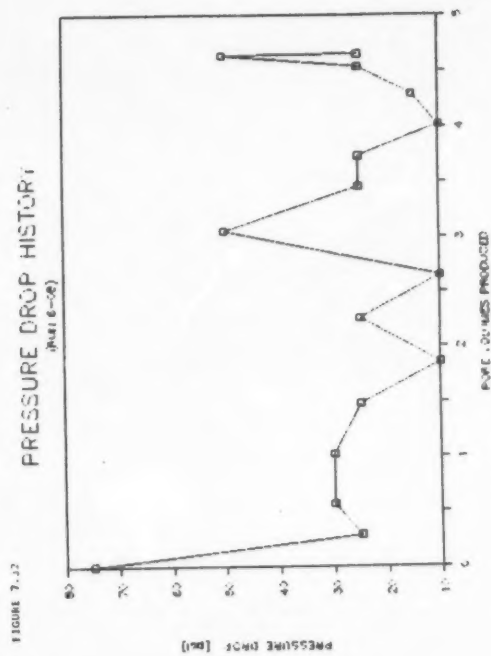
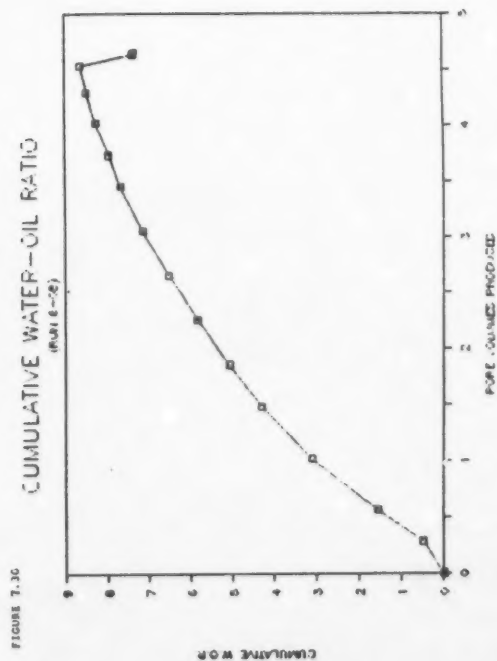
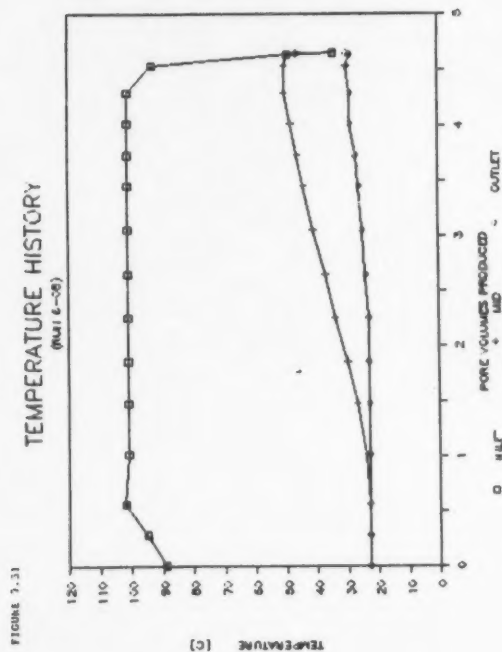
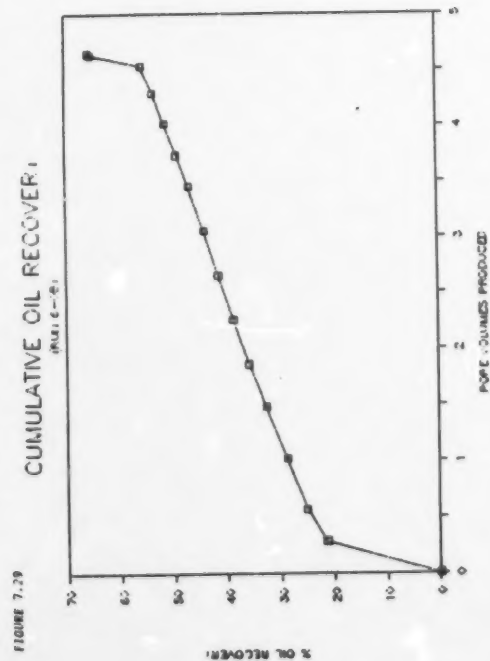


FIGURE 7.33

CUMULATIVE OIL RECOVERY

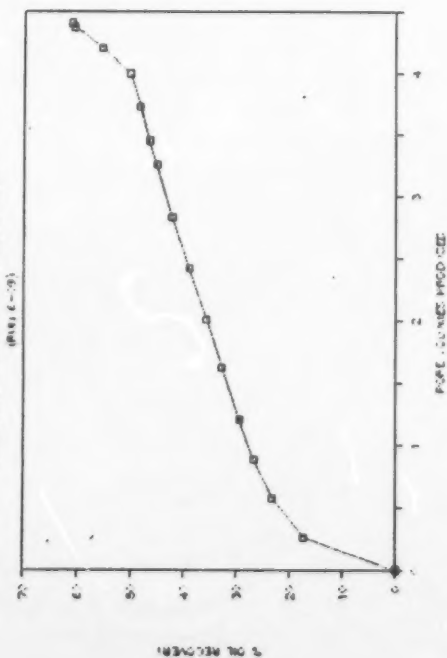


FIGURE 7.35

TEMPERATURE HISTORY

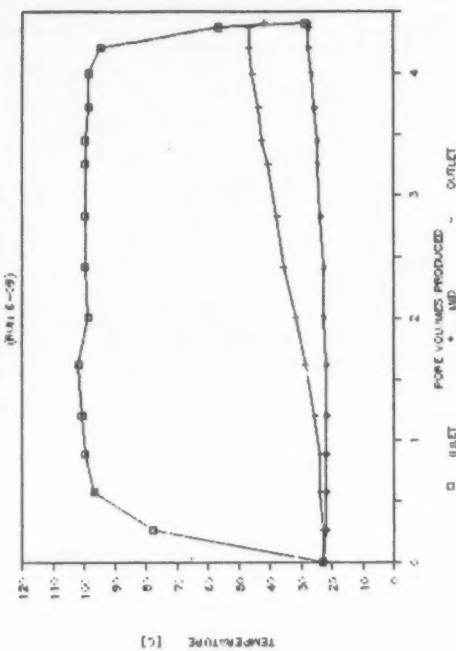


FIGURE 7.34

CUMULATIVE WATER-OIL RATIO

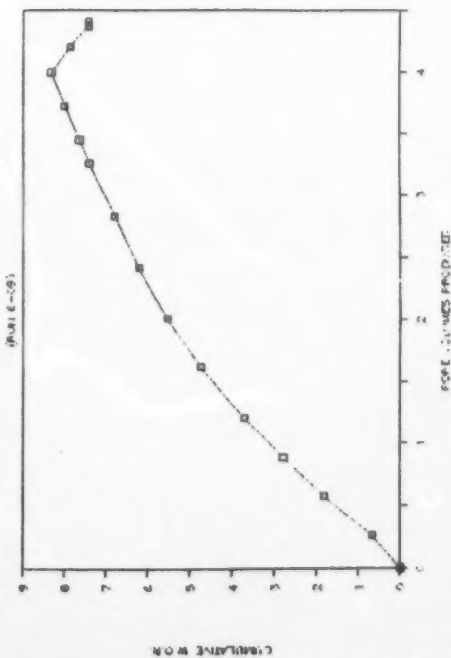
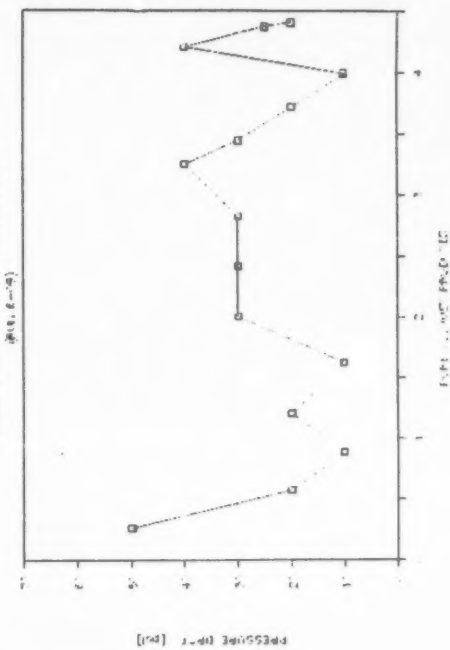


FIGURE 7.36

PRESSURE DROP HISTORY



(TABLE A-40)

FIGURE 7.37

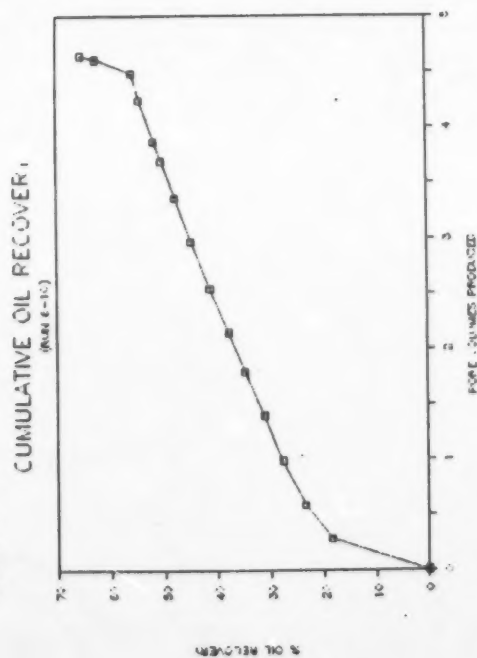


FIGURE 7.39

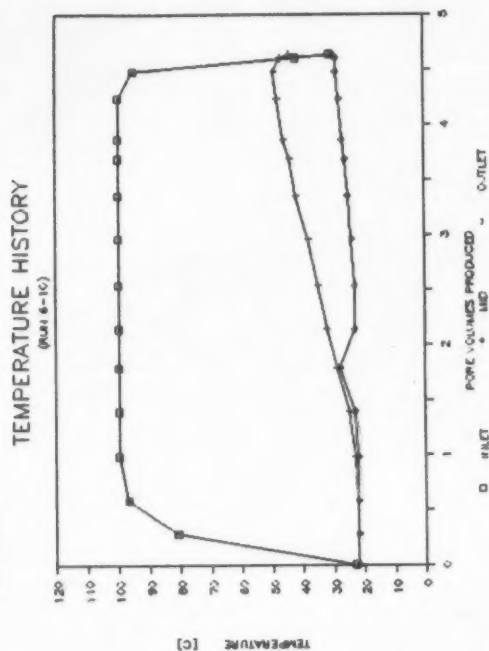


FIGURE 7.38

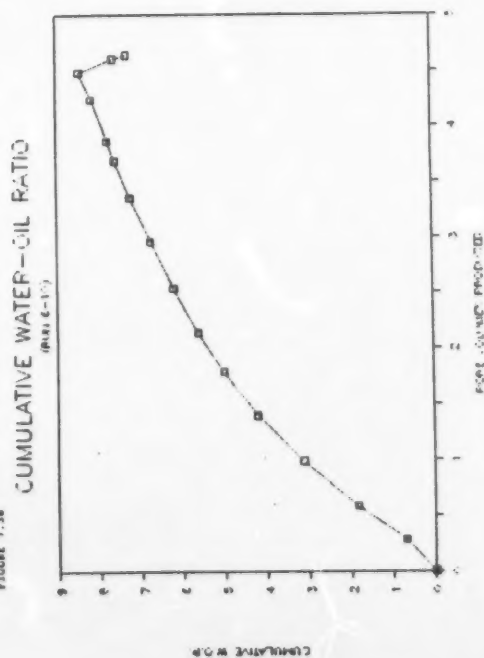
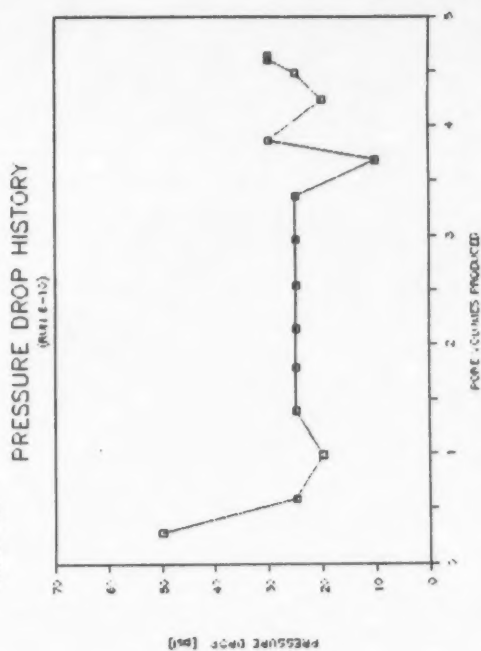


FIGURE 7.40



(TABLE A-41)

FIGURE 7.41

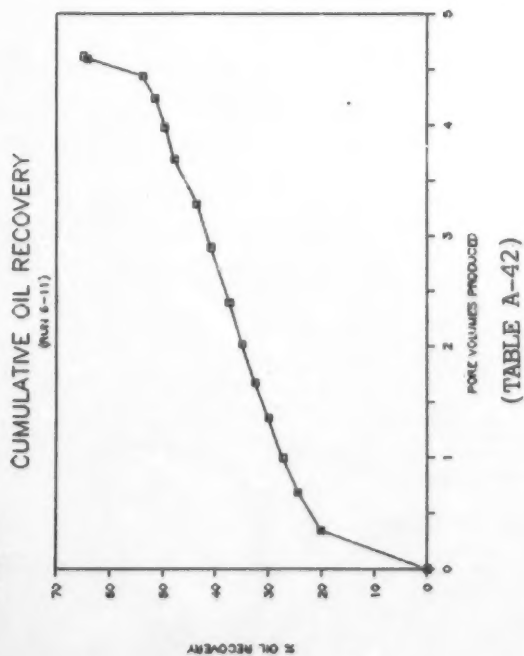


FIGURE 7.43

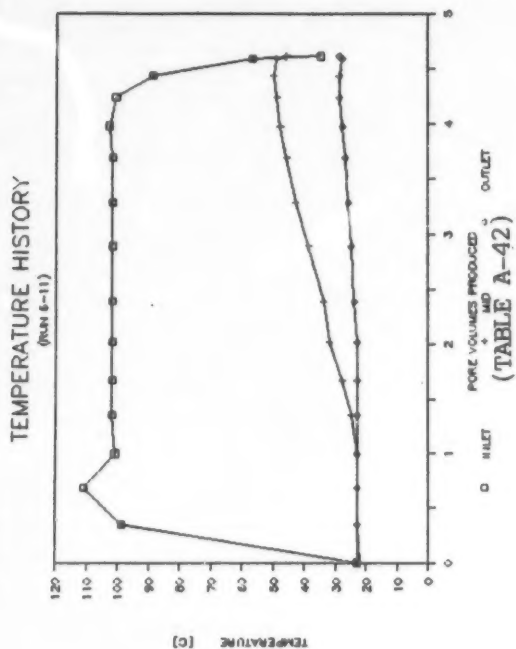


FIGURE 7.42

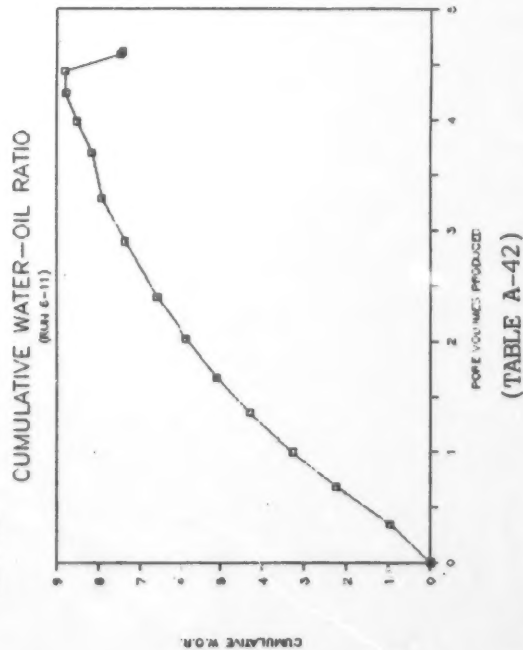


FIGURE 7.44

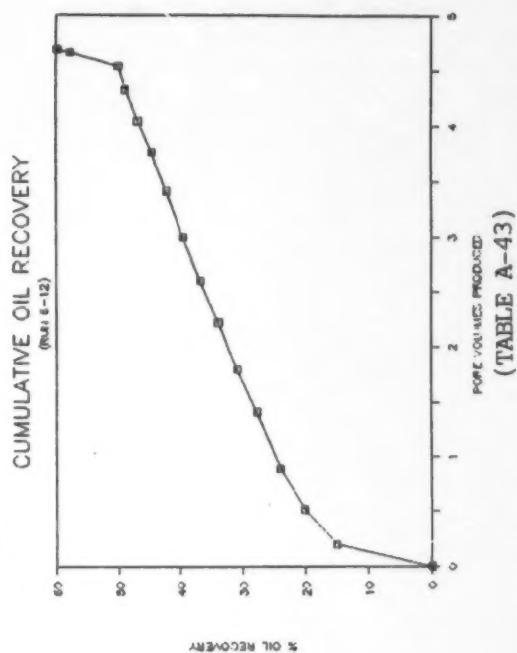


FIGURE 7.45

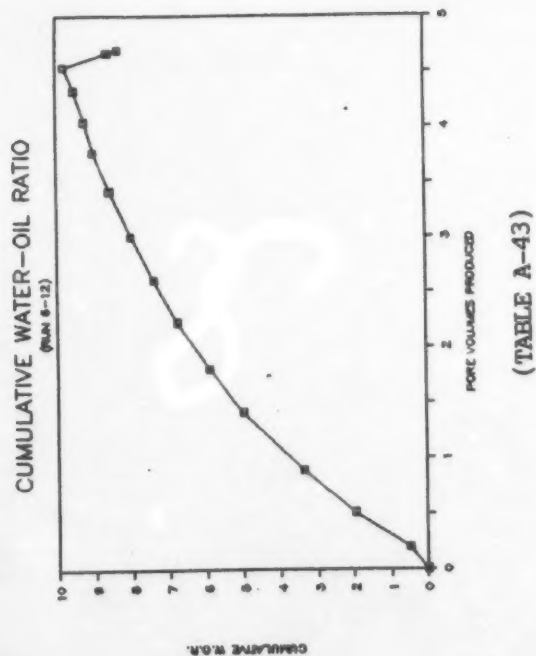


FIGURE 7.47

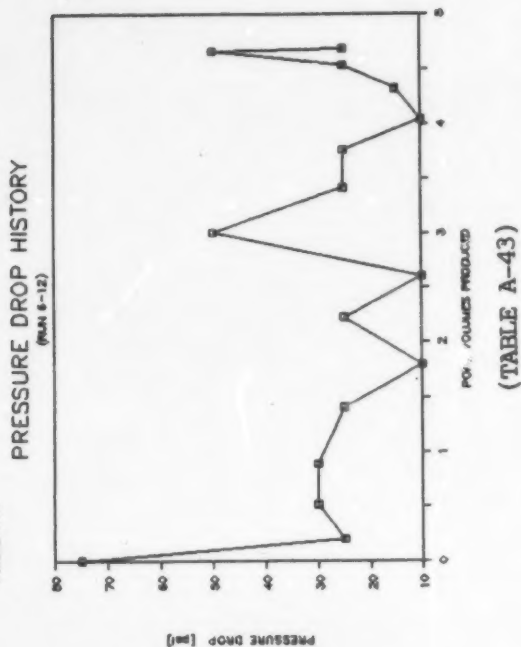


FIGURE 7.46

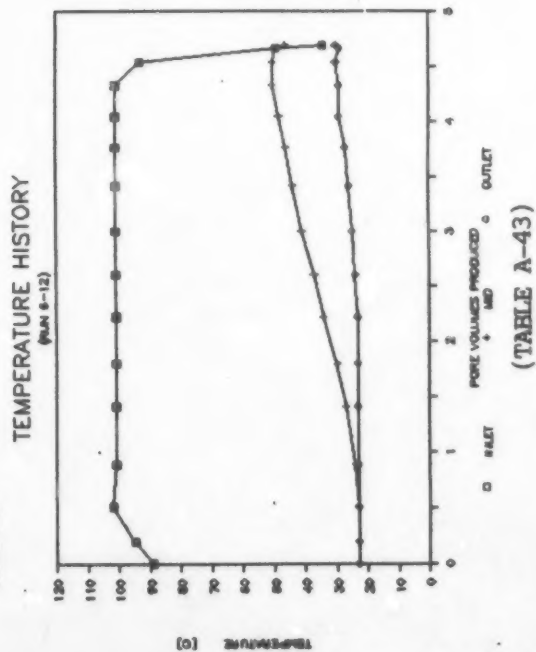


FIGURE 7.48

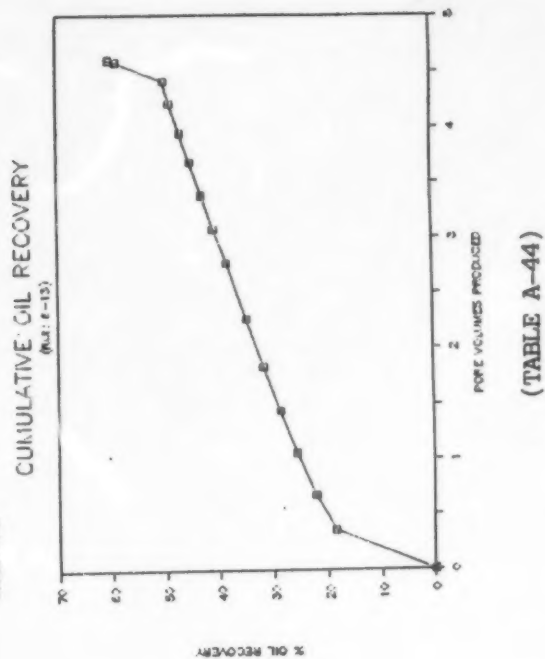


FIGURE 7.40

# CUMULATIVE WATER-OIL RATIO

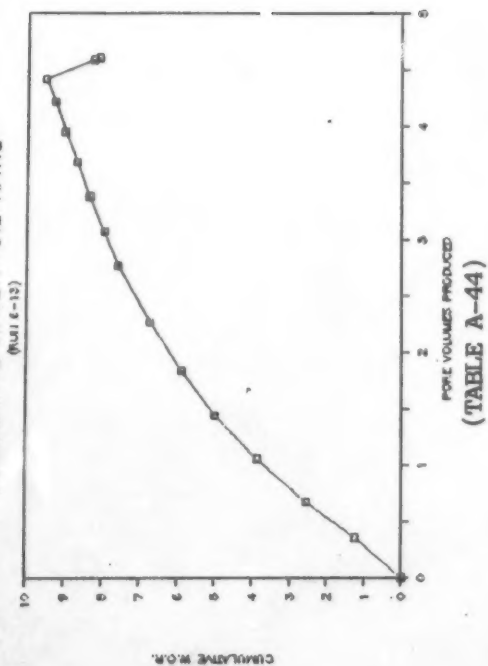


FIGURE 7.51

# PRESSURE DROP HISTORY

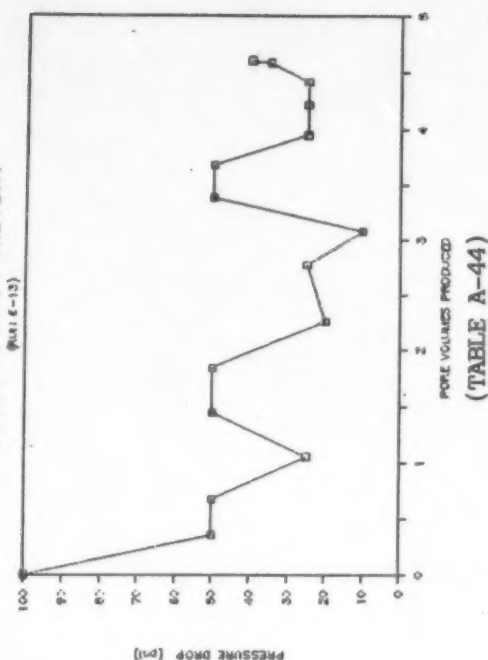


FIGURE 7.50

# TEMPERATURE HISTORY

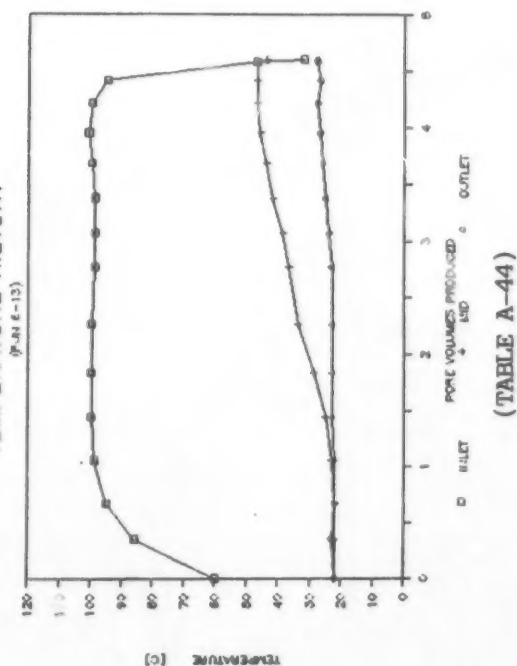


FIGURE 7.52

# CUMULATIVE OIL RECOVERY

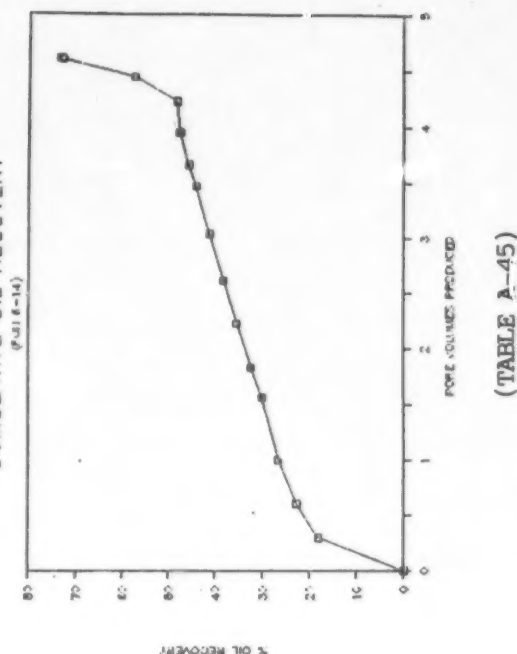
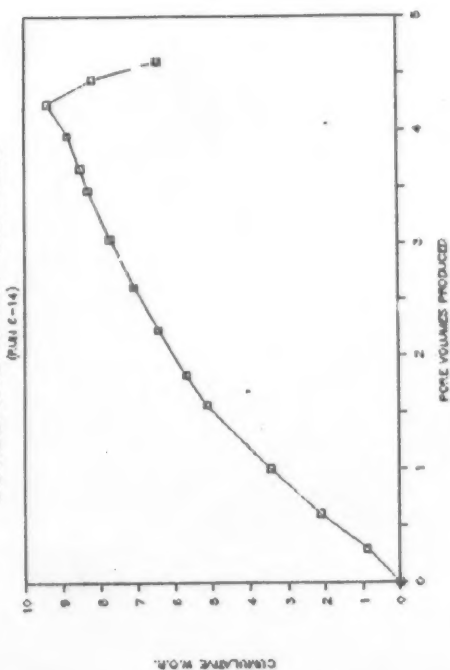


FIGURE 7.53

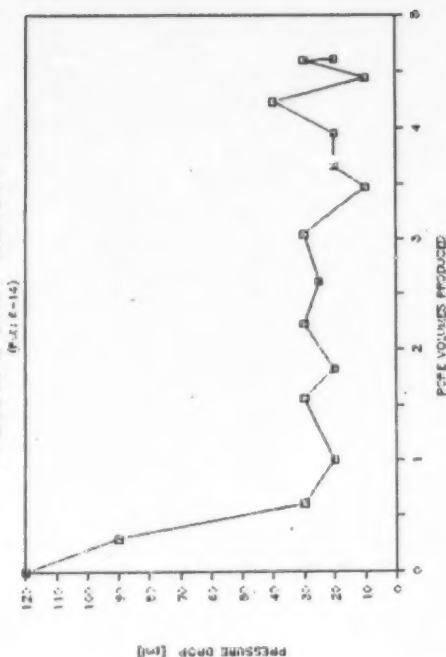
CUMULATIVE WATER-OIL RATIO



(TABLE A-45)

FIGURE 7.55

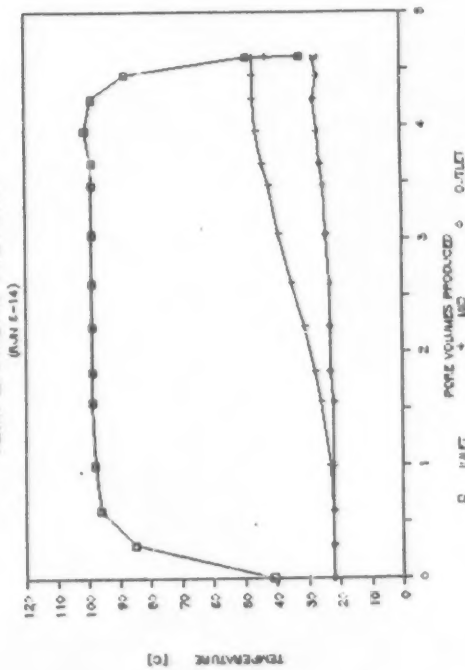
PRESSURE DROP HISTORY



(TABLE A-45)

FIGURE 7.54

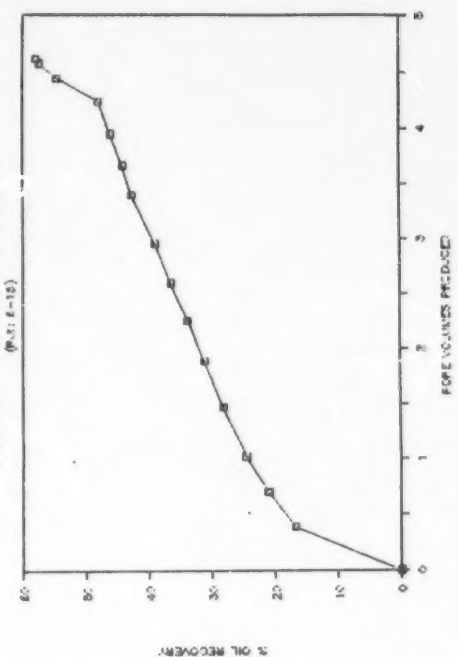
TEMPERATURE HISTORY



(TABLE A-45)

FIGURE 7.56

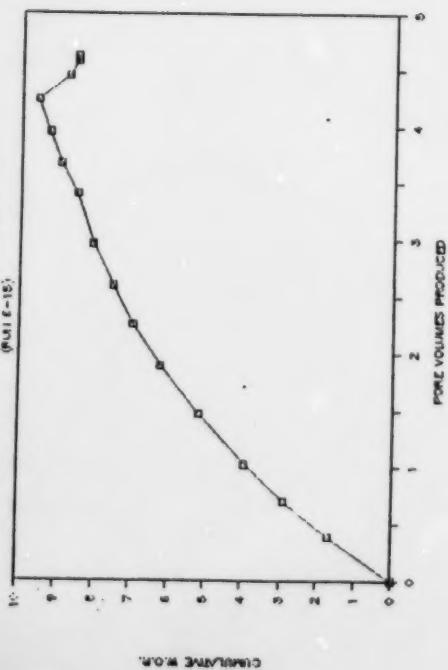
CUMULATIVE OIL RECOVERY



(TABLE A-46)

FIGURE 7.57.

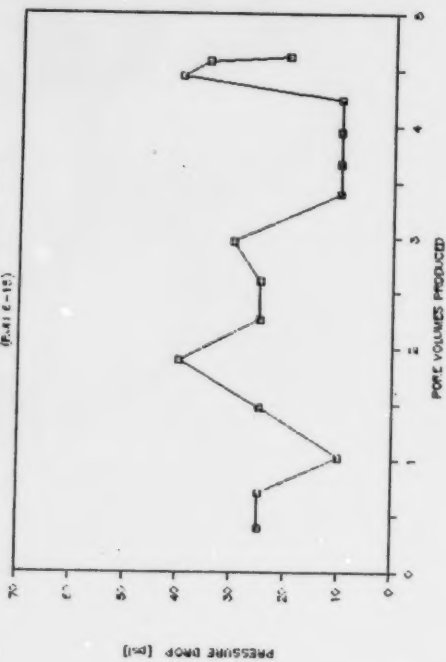
CUMULATIVE WATER-OIL RATIO  
(TABLE A-46)



(TABLE A-46)

FIGURE 7.59

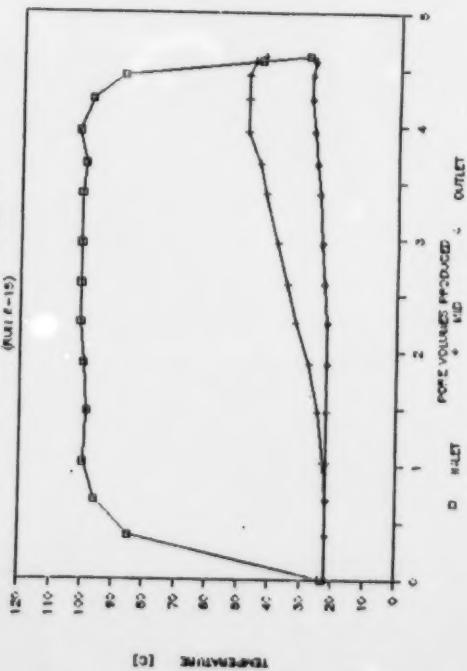
PRESSURE DROP HISTORY  
(TABLE A-46)



(TABLE A-46)

FIGURE 7.56

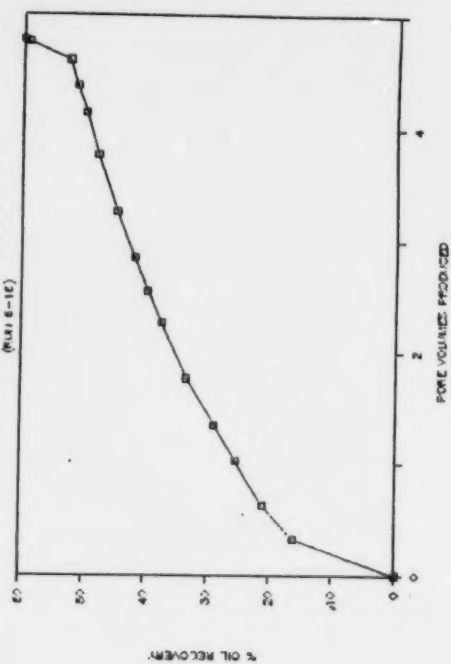
TEMPERATURE HISTORY  
(TABLE A-46)



(TABLE A-46)

FIGURE 7.60

CUMULATIVE OIL RECOVERY  
(TABLE A-47)

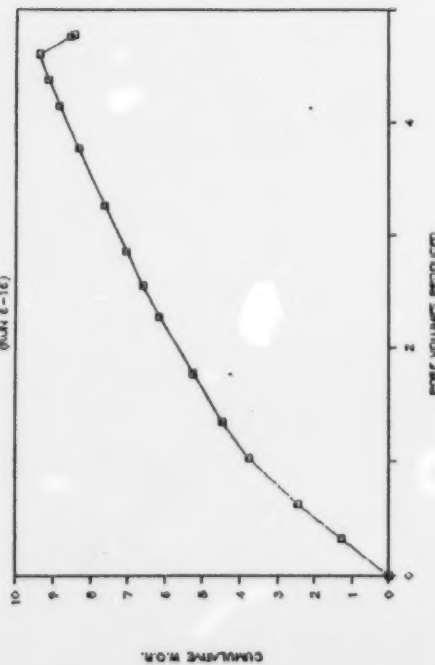


(TABLE A-47)

FIGURE 7.61

CUMULATIVE WATER-OIL RATIO

(DATA 6-16)

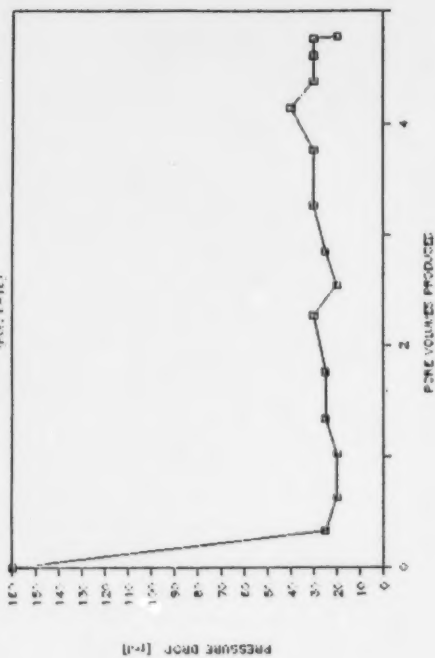


(TABLE A-47)

FIGURE 7.63

PRESSURE DROP HISTORY

(DATA 6-16)

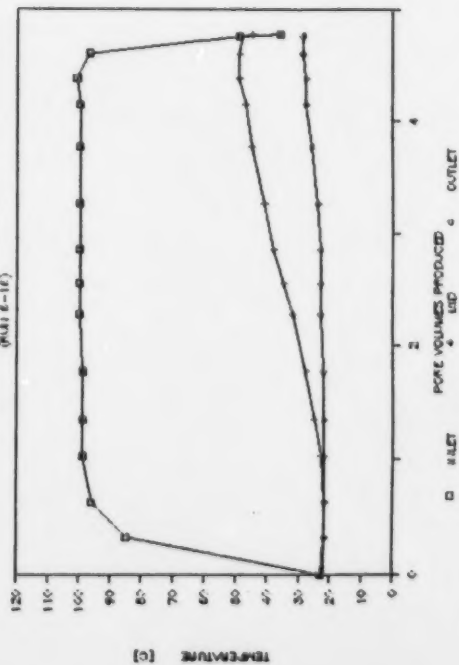


(TABLE A-47)

FIGURE 7.62

TEMPERATURE HISTORY

(DATA 6-16)



(TABLE A-47)

TABLE 7.2

OIL/ADDITIVE/SALT INTERACTIONS/  
OIL RECOVERY ENHANCEMENT INDEX

| <u>EXPERIMENT</u> | <u>OREI</u> |
|-------------------|-------------|
| 6-01              | 6.6         |
| 6-02              | 5.7         |
| 6-03              | 3.9         |
| 6-04              | 2.0         |
| 6-05              | 4.5         |
| 6-06              | 4.2         |
| 6-07              | 4.0         |
| 6-08              | 3.0         |
| 6-09              | 2.9         |
| 6-10              | 2.1         |
| 6-11              | 2.8         |
| 6-12              | 2.8         |
| 6-13              | 2.8         |
| 6-14              | 5.8         |
| 6-15              | 2.6         |
| 6-16              | 2.4         |

## ANALYSIS OF VARIANCE TABLES

EFFECT OF ADDITIVES  
\*\*\*\*\*TABLE (A)  
ANOVA TABLE

|                    |     | F1       | F1   | F2   | F2   |
|--------------------|-----|----------|------|------|------|
|                    |     | O1       | O2   | O1   | O2   |
| C1                 | A1  | 6.6      | 4.5  | 2.9  | 2.8  |
| C1                 | A2  | 3.9      | 4    | 2.1  | 2.8  |
| C2                 | A1  | 5.7      | 4.2  | 2.6  | 5.8  |
| C2                 | A2  | 2        | 3    | 2.4  | 2.8  |
| SUM COLUMNS        |     | 18.2     | 15.7 | 10   | 14.2 |
| SUM FORMATN SALT:  | F1= | 33.9     | F2=  | 24.2 |      |
| SUM OILS:          | O1= | 28.2     | O2=  | 29.9 |      |
| SUM ADDITIVE CONC: | C1= | 29.6     | C2=  | 28.5 |      |
| SUM ADDITIVE TYPE: | A1= | 35.1     | A2=  | 23   |      |
| GRAND SUM          |     | 58.1     |      |      |      |
| CORRECTION         |     | 210.9756 |      |      |      |
| TOTAL VARIANCE SS  |     | 29.67437 |      |      |      |

TABLE (B)

| INTERACTION TABLE | SALT X OIL |     |          | SUM SALT |
|-------------------|------------|-----|----------|----------|
| SALT              | PELICAN    | OIL | B.COULEE |          |
| F1                | 18.2       |     | 15.7     | 33.9     |
| F2                | 10         |     | 14.2     | 24.2     |
| SUM OIL           | 28.2       |     | 29.9     |          |

SS [TOT] = 8.866875  
 SS [SALT] = 5.880625  
 SS [OIL] = 0.180625

TABLE (C)

| INTERACTION TABLE | FORMTN-SALT X ADDVE-CONC |        | SUM SALT |
|-------------------|--------------------------|--------|----------|
| SALT              | C-LOW                    | C-HIGH |          |
| F1                | 19                       | 14.9   | 33.9     |
| F2                | 10.6                     | 13.6   | 24.2     |
| SUM ADDVE-CONC    | 29.6                     | 28.5   |          |

SS [TOT] = 9.106875  
 SS [SALT] = 5.880625  
 SS [CONC] = 0.075625

TABLE (D)

| INTERACTION TABLE | FORMTN-SALT X ADDVE-TYPE |      | SUM SALT |
|-------------------|--------------------------|------|----------|
| FORMTN-SALT       | NAOH                     | TRS  |          |
| F1                | 21                       | 12.9 | 33.9     |
| F2                | 14.1                     | 10.1 | 24.2     |
| SUM ADDVE-TYPE    | 35.1                     | 23   |          |

SS [TOT] = 16.08187  
 SS [SALT] = 5.880625  
 SS [A-TYPE] = 9.150625

TABLE (E)

| INTERACTION TABLE | OIL X ADDVE-CONC |        | SUM OIL |
|-------------------|------------------|--------|---------|
|                   | ADDVE-CONC       |        |         |
| OIL               | C-LOW            | C-HIGH |         |
| PELICAN           | 15.5             | 12.7   | 28.2    |
| B.COULEE          | 14.1             | 15.8   | 29.9    |
| SUM ADDVE-CONC    | 29.6             | 28.5   |         |

SS [TOT] = 1.521875  
 SS [OIL] = 0.180625  
 SS [CONC] = 0.075625

TABLE (F)

| INTERACTION TABLE |                | OIL X ADDVE-TYPE | ADDVE-TYPE | TRS  | SUM OIL |
|-------------------|----------------|------------------|------------|------|---------|
|                   | OIL            | NAOH             |            |      |         |
|                   | PELICAN        | 17.8             |            | 10.4 | 28.2    |
|                   | B.COULEE       | 17.3             |            | 12.6 | 29.9    |
|                   | SUM ADDVE-TYPE | 35.1             |            | 23   |         |
| SS [TOT] =        |                | 9.786875         |            |      |         |
| SS [OIL] =        |                | 0.180625         |            |      |         |
| SS [TYPE] =       |                | 9.150625         |            |      |         |

TABLE (G)

| INTERACTION TABLE |                | ADDVE-CONC X ADDVE-TYPE | ADDVE-TYPE | TRS  | SUM CONC |
|-------------------|----------------|-------------------------|------------|------|----------|
|                   | ADDVE-CONC     | NAOH                    |            |      |          |
|                   | C-LOW          | 16.8                    |            | 12.8 | 29.6     |
|                   | C-HIGH         | 18.3                    |            | 10.2 | 28.5     |
|                   | SUM ADDVE-TYPE | 35.1                    |            | 23   |          |
| SS [TOT] =        |                | 10.27687                |            |      |          |
| SS [CONC] =       |                | 0.075625                |            |      |          |
| SS [TYPE] =       |                | 9.150625                |            |      |          |

TABLE (H)

| SALT X OIL ANOVA TABLE |                        | df | SS       | MS       |
|------------------------|------------------------|----|----------|----------|
|                        | SOURCE                 |    |          |          |
|                        | BETWEEN FORMATION SALT | 1  | 5.880625 | 5.880625 |
|                        | BETWEEN OILS           | 1  | 0.180625 | 0.180625 |
|                        | SALT X OIL INTERACTION | 1  | 2.805625 | 2.805625 |
|                        |                        | 3  | 8.866875 |          |

TABLE (I)

| FORMATN SALT X ADDVE-CONC ANOVA TABLE |                             | df | SS       | MS       |
|---------------------------------------|-----------------------------|----|----------|----------|
|                                       | SOURCE                      |    |          |          |
|                                       | BETWEEN SALT                | 1  | 5.880625 | 5.880625 |
|                                       | BETWEEN ADDVE-CONC          | 1  | 0.075625 | 0.075625 |
|                                       | SALT X ADDVE-CONC INTERACTN | 1  | 3.150625 | 3.150625 |
|                                       |                             | 3  | 9.106875 |          |

TABLE (J)

| SALT X TYPE ANOVA TABLE |                         | df | SS       | MS       |
|-------------------------|-------------------------|----|----------|----------|
|                         | SOURCE                  |    |          |          |
|                         | BETWEEN FORMATN SALT    | 1  | 5.880625 | 5.880625 |
|                         | BETWEEN ADDITIVE TYPE   | 1  | 9.150625 | 9.150625 |
|                         | SALT X TYPE INTERACTION | 1  | 1.050625 | 1.050625 |
|                         |                         | 3  | 16.08187 |          |

TABLE (K)

| OIL X ADDVE-CONC ANOVA TABLE |                            | df | SS       | MS       |
|------------------------------|----------------------------|----|----------|----------|
|                              | SOURCE                     |    |          |          |
|                              | BETWEEN OILS               | 1  | 0.180625 | 0.180625 |
|                              | BETWEEN ADDVE-CONC         | 1  | 0.075625 | 0.075625 |
|                              | OIL X ADDVE-CONC INTERACTN | 1  | 1.265625 | 1.265625 |
|                              |                            | 3  | 1.521875 |          |

TABLE (L)

OIL X ADDITIVE TYPE ANOVA TABLE

| SOURCE                 | df | SS       | MS       |
|------------------------|----|----------|----------|
| BETWEEN OILS           | 1  | 0.180625 | 0.180625 |
| BETWEEN ADDITIVE TYPES | 1  | 9.150625 | 9.150625 |
| OIL X TYPE INTERACTION | 1  | 0.455625 | 0.455625 |
|                        | 3  | 9.786875 |          |

TABLE (M)

ADDITIVE CONC X ADDITIVE TYPE ANOVA TABLE

| SOURCE                  | df | SS       | MS       |
|-------------------------|----|----------|----------|
| BETWEEN ADDITIVE CONC   | 1  | 0.075625 | 0.075625 |
| BETWEEN ADDITIVE TYPE   | 1  | 9.150625 | 9.150625 |
| CONC X TYPE INTERACTION | 1  | 1.050625 | 1.050625 |
|                         | 3  | 10.27687 |          |

TABLE (N)

| SOURCE                    | df | SS        | MS       | F.VALUE  |
|---------------------------|----|-----------|----------|----------|
| BETWEEN FORMATION SALTS   | 1  | 5.880625  | 5.880625 | 6.380713 |
| BETWEEN OILS              | 1  | 0.180625  | 0.180625 | 0.195985 |
| BETWEEN ADDITIVE CONCS    | 1  | 0.075625  | 0.075625 | 0.082056 |
| BETWEEN ADDITIVE TYPES    | 1  | 9.150625  | 9.150625 | 9.928794 |
| F X O INTERACTION         | 1  | 2.805625  | 2.805625 |          |
| F X C INTERACTION         | 1  | 3.150625  | 3.150625 |          |
| F X A INTERACTION         | 1  | 1.050625  | 1.050625 |          |
| O X C INTERACTION         | 1  | 1.265625  | 1.265625 |          |
| O X A INTERACTION         | 1  | 0.455625  | 0.455625 |          |
| C X A INTERACTION         | 1  | 1.050625  | 1.050625 |          |
| HIGHER ORDER INTERACTIONS | 5  | 4.608125  | 0.921625 |          |
|                           | 15 | 29.674375 |          |          |

F 0.05 [1/5] = 6.61  
ADDITIVE TYPE .. SIGNIFICANT

TABLE 7.4

SUMMARY TABLE  
EFFECT OF ADDITIVES

| RUN # | TABLE # | TEMP C | W RATE ML/H | G RATE L/H | PRESS PSIG | OIL      | GAS | ADDVE  | SAND MESH | SALT CONC G/L | D.R.E.I. | RECOVERY % |
|-------|---------|--------|-------------|------------|------------|----------|-----|--------|-----------|---------------|----------|------------|
| 6-01  | A32     | 102    | 530         | 36         | 100        | PLCN     | N2  | NaOH/L | 55        | 1             | 6.6      | 76.3       |
| 6-02  | A33     | 102    | 530         | 36         | 100        | PLCN     | N2  | NaOH/H | 55        | 1             | 5.7      | 75.4       |
| 6-03  | A34     | 101    | 530         | 36         | 100        | PLCN     | N2  | TRS/L  | 55        | 1             | 3.9      | 68.6       |
| 6-04  | A35     | 100    | 530         | 36         | 100        | PLCN     | N2  | TRS/H  | 55        | 1             | 2        | 64.1       |
| 6-05  | A36     | 102    | 530         | 36         | 100        | B. COLEE | N2  | NaOH/L | 55        | 1             | 4.5      | 62         |
| 6-06  | A37     | 101    | 530         | 36         | 100        | B. COLEE | N2  | NaOH/H | 55        | 1             | 4.2      | 64         |
| 6-07  | A38     | 100    | 530         | 36         | 100        | B. COLEE | N2  | TRS/L  | 55        | 1             | 4        | 66.4       |
| 6-08  | A39     | 102    | 530         | 36         | 100        | B. COLEE | N2  | TRS/H  | 55        | 1             | 3        | 65.7       |
| 6-09  | A40     | 102    | 530         | 36         | 100        | PLCN     | N2  | NaOH/L | 55        | 5             | 2.9      | 61.2       |
| 6-10  | A41     | 102    | 530         | 36         | 100        | PLCN     | N2  | TRS/L  | 55        | 5             | 2.1      | 65.5       |
| 6-11  | A42     | 103    | 530         | 36         | 100        | B. COLEE | N2  | NaOH/L | 55        | 5             | 2.8      | 65         |
| 6-12  | A43     | 105    | 530         | 36         | 100        | B. COLEE | N2  | TRS/L  | 55        | 5             | 2.8      | 59.9       |
| 6-13  | A44     | 100    | 530         | 36         | 100        | B. COLEE | N2  | TRS/H  | 55        | 5             | 2.8      | 60.17      |
| 6-14  | A45     | 101    | 530         | 36         | 100        | B. COLEE | N2  | NaOH/H | 55        | 5             | 5.8      | 73.3       |
| 6-15  | A46     | 105    | 530         | 36         | 100        | PLCN     | N2  | NaOH/H | 55        | 5             | 2.6      | 58         |
| 6-16  | A47     | 102    | 530         | 36         | 100        | PLCN     | N2  | TRS/H  | 55        | 5             | 2.4      | 59.9       |

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APPENDIX A

CORE DISPLACEMENT TABLES

COMMISSIONING RUN #1  
TEMPERATURE 20C  
PELICAN LAKE CRUDE  
5 G/L BRINE  
55 MESH SAND 1761.5 G

TABLE A.1 - 97 -  
AVG FEED RATE ML/H 196  
OUTLET PRESS PSIG 175  
PV ML 433  
TOT OIL ML 433

| SAMPLE # | PV INJ | OIL PROD | H2O PROD | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|--------|----------|----------|---------|---------|---------|---------|
|          | 0      | 0        | 0        | 0       | 0       | 0.00    | 0.00    |
| 1-8      | 0.045  | 19.66    | 0        | 19.66   | 0       | 0.00    | 4.54    |
| 9-10     | 0.087  | 18.77    | 1.07     | 36.43   | 1.07    | 0.03    | 8.41    |
| 11       | 0.112  | 6.4      | 4.55     | 42.83   | 5.62    | 0.13    | 9.89    |
| 12       | 0.143  | 4.93     | 8.64     | 47.76   | 14.26   | 0.30    | 11.03   |
| 13       | 0.15   | 5.49     | 10.26    | 53.25   | 24.52   | 0.46    | 12.30   |
| 14       | 0.216  | 5.68     | 10       | 58.93   | 34.52   | 0.59    | 13.61   |
| 15       | 0.265  | 5.73     | 15.54    | 64.66   | 50.06   | 0.77    | 14.93   |
| 16       | 0.306  | 5.37     | 12.32    | 70.03   | 62.38   | 0.89    | 16.17   |
| 17       | 0.336  | 2.98     | 10.07    | 73.01   | 72.45   | 0.99    | 16.86   |
| 18       | 0.373  | 4.12     | 12.14    | 77.13   | 84.59   | 1.10    | 17.81   |
| 19       | 0.412  | 3.28     | 13.47    | 80.41   | 98.06   | 1.22    | 18.57   |
| 20       | 0.455  | 3.14     | 15.4     | 83.55   | 113.46  | 1.36    | 19.30   |
| 21       | 0.498  | 2.94     | 15.52    | 86.49   | 128.98  | 1.49    | 19.97   |
| 22       | 0.534  | 1.83     | 13.72    | 88.32   | 142.7   | 1.62    | 20.40   |
| 23       | 0.58   | 2.29     | 17.74    | 90.61   | 160.44  | 1.77    | 20.93   |
| 24       | 0.633  | 2.41     | 20.56    | 93.02   | 181     | 1.95    | 21.48   |
| 25       | 0.655  | 2.36     | 20.44    | 95.38   | 201.44  | 2.11    | 22.03   |
| 26       | 0.736  | 2.36     | 19.74    | 97.74   | 221.18  | 2.26    | 22.57   |
| 27       | 0.788  | 1.88     | 20.4     | 99.62   | 241.58  | 2.43    | 23.01   |
| 28       | 0.84   | 1.85     | 20.54    | 101.47  | 262.12  | 2.58    | 23.43   |
| 29       | 0.889  | 1.54     | 19.93    | 103.01  | 283.05  | 2.74    | 23.79   |
| 30       | 0.948  | 1.99     | 22.47    | 105     | 304.52  | 2.90    | 24.25   |
| 31       | 0.997  | 1.58     | 20.72    | 106.58  | 325.24  | 3.05    | 24.61   |
| 32       | 1.05   | 1.56     | 20.44    | 108.14  | 345.68  | 3.20    | 24.97   |
| 33       | 1.1    | 1.22     | 22.2     | 109.36  | 367.08  | 3.36    | 25.26   |
| 34       | 1.16   | 1.37     | 26.06    | 110.73  | 393.94  | 3.56    | 25.57   |
| 35       | 1.22   | 1.45     | 21.7     | 112.18  | 415.64  | 3.71    | 25.91   |
| 36       | 1.27   | 1.24     | 22.2     | 113.42  | 437.84  | 3.86    | 26.19   |
| 37       | 1.31   | 0.93     | 15.51    | 114.35  | 453.35  | 3.96    | 26.41   |
| 38       | 1.35   | 1.05     | 17.09    | 115.4   | 470.44  | 4.08    | 26.65   |
| 39       | 1.4    | 0.76     | 20.1     | 116.16  | 490.54  | 4.22    | 26.83   |
| 40       | 1.46   | 1        | 22.85    | 117.16  | 513.39  | 4.38    | 27.06   |
| 41       | 1.51   | 0.8      | 20.8     | 117.96  | 534.19  | 4.53    | 27.24   |
| 42       | 1.57   | 0.92     | 25       | 118.88  | 559.19  | 4.70    | 27.45   |
| 43       | 1.62   | 0.89     | 20.52    | 119.77  | 579.71  | 4.84    | 27.66   |
| 44       | 1.65   | 0.77     | 15.67    | 120.54  | 595.38  | 4.94    | 27.84   |
| 45       | 1.72   | 1.43     | 25.6     | 121.97  | 620.98  | 5.09    | 28.17   |
| 46       | 1.77   | 0.76     | 23.94    | 122.73  | 644.92  | 5.25    | 28.34   |
| 47       | 1.84   | 1.38     | 26.8     | 124.11  | 671.72  | 5.41    | 28.66   |
| 48       | 1.89   | 1.03     | 21.75    | 125.14  | 693.47  | 5.54    | 28.90   |
| 49       | 1.94   | 1.32     | 21.06    | 126.46  | 714.53  | 5.65    | 29.21   |
| 50       | 2      | 1.03     | 22.49    | 127.49  | 737.02  | 5.78    | 29.44   |
| 51       | 2.09   | 1.51     | 40.75    | 129     | 777.77  | 6.03    | 29.79   |
| 52       | 2.21   | 1.89     | 49.74    | 130.89  | 827.51  | 6.32    | 30.23   |
| 53       | 2.31   | 1.61     | 40.95    | 132.5   | 868.46  | 6.55    | 30.60   |
| 54       | 2.42   | 1.43     | 46.7     | 133.93  | 915.16  | 6.83    | 30.93   |
| 55       | 2.53   | 1.15     | 43.74    | 135.08  | 958.9   | 7.10    | 31.20   |
| 56       | 2.65   | 2.32     | 49.2     | 137.4   | 1008.1  | 7.34    | 31.73   |
| 57       | 2.74   | 2.37     | 39.69    | 139.77  | 1047.79 | 7.50    | 32.28   |
| 58       | 2.84   | 2.4      | 40.39    | 142.17  | 1088.18 | 7.65    | 32.83   |
| 59       | 2.94   | 1.84     | 39.56    | 144.01  | 1127.74 | 7.83    | 33.26   |
| 60       | 3.05   | 1.25     | 48.65    | 145.26  | 1176.39 | 8.10    | 33.55   |
| 61       | 3.19   | 1.58     | 55.99    | 146.84  | 1232.38 | 8.39    | 33.91   |
| 62       | 3.32   | 1.19     | 56.56    | 148.03  | 1288.94 | 8.71    | 34.19   |
| 63       | 3.44   | 1.4      | 52.88    | 149.43  | 1341.82 | 8.98    | 34.51   |
| 64       | 3.57   | 0.75     | 53.59    | 150.18  | 1395.41 | 9.29    | 34.68   |
| 65       | 3.67   | 0.67     | 43.61    | 150.85  | 1439.02 | 9.54    | 34.84   |
| 66       | 3.77   | 0.74     | 43.46    | 151.59  | 1482.48 | 9.78    | 35.01   |
| 67       | 3.88   | 1.01     | 45.3     | 152.6   | 1527.78 | 10.01   | 35.24   |
| 68       | 4      | 0.9      | 48.79    | 153.5   | 1576.57 | 10.27   | 35.45   |
| 69       | 4.08   | 0.88     | 33.52    | 154.38  | 1610.09 | 10.43   | 35.65   |
| 70       | 4.17   | 1.12     | 38.71    | 155.5   | 1648.8  | 10.60   | 35.91   |

COMMISSIONING RUN #2

TABLE A.2

TEMPERATURE 500  
PELICAN LAKE CRUDE  
5 G/L BRINE  
55 MESH SAND 1761.5 G

AVG FEED RATE ML/H  
OUTLET PRESS PSIG  
PV ML  
TOT OIL G

246.6  
175  
422.3  
371.2

| SAMPLE # | PV INJ G | OIL PD G | H2O PD G | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|----------|----------|----------|---------|---------|---------|---------|
| 1        | 0.102    | 31.65    | 1.18     | 31.65   | 1.18    | 0.00    | 0.00    |
| 2        | 0.1      | 17.62    | 14.81    | 49.27   | 15.99   | 0.04    | 6.52    |
| 3        | 0.3      | 10.61    | 22.32    | 59.88   | 38.31   | 0.32    | 13.27   |
| 4        | 0.4      | 17.89    | 25.13    | 77.77   | 63.5    | 0.64    | 18.13   |
| 5        | 0.5      | 5.94     | 27.67    | 83.71   | 91.17   | 0.94    | 18.25   |
| 6        | 0.7      | 9.25     | 56.82    | 92.96   | 148     | 1.24    | 19.55   |
| 7        | 0.9      | 7.6      | 59.14    | 100.56  | 207.14  | 1.78    | 24.32   |
| 8        | 1.07     | 6.02     | 62.61    | 106.58  | 269.75  | 2.29    | 24.32   |
| 9        | 1.259    | 4.96     | 53.42    | 111.54  | 323.23  | 2.79    | 26.01   |
| 10       | 1.499    | 3.85     | 62.1     | 115.39  | 385.33  | 3.24    | 27.35   |
| 11       | 1.703    | 4.54     | 65.12    | 120.93  | 450.45  | 3.73    | 28.30   |
| 12       | 1.899    | 4.72     | 60.67    | 125.65  | 511.32  | 4.14    | 29.63   |
| 13       | 2.099    | 3.7      | 63.06    | 129.35  | 574.37  | 4.50    | 30.90   |
| 14       | 2.298    | 3.43     | 63.59    | 132.78  | 637.96  | 4.89    | 31.90   |
| 15       | 2.498    | 2.96     | 64.25    | 135.74  | 702.21  | 5.28    | 32.83   |
| 16       | 2.698    | 2.46     | 64.18    | 138.20  | 766.39  | 5.69    | 33.51   |
| 17       | 2.898    | 2.07     | 64.11    | 140.27  | 830.50  | 6.06    | 34.20   |
| 18       | 3.098    | 1.67     | 64.11    | 141.94  | 894.61  | 6.17    | 35.32   |
| 19       | 3.298    | 1.29     | 64.12    | 143.23  | 958.72  | 6.54    | 37.04   |
| 20       | 3.498    | 0.9      | 64.12    | 144.13  | 1022.81 | 6.84    | 37.82   |
| 21       | 3.697    | 0.5      | 64.58    | 144.63  | 1086.95 | 7.18    | 38.44   |
| 22       | 3.897    | 0.1      | 63.58    | 144.73  | 1150.73 | 7.61    | 39.27   |
| 23       | 4.097    | 0.1      | 63.64    | 144.83  | 1214.37 | 7.91    | 39.27   |
| 24       | 4.297    | 0.1      | 63.64    | 144.93  | 1278.01 | 8.17    | 40.11   |

COMMISSIONING RUN #3

TABLE A.3

TEMPERATURE 1200C  
PELICAN LAKE CRUDE  
5 G/L BRINE  
55 MESH SAND 1762.35 G

AVG FEED RATE ML/H  
OUTLET PRESS PSIG  
PV ML  
TOT OIL G

246.6  
175  
422.1  
379.34

| SAMPLE # | PV INJ G | OIL PD G | H2O PD G | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|----------|----------|----------|---------|---------|---------|---------|
| 1        | 0.000    |          |          |         |         | 0       | 0.00    |
| 2        | 0.273    | 24.83    | 6.32     | 24.83   | 6.32    | 0.25    | 6.55    |
| 3        | 0.528    | 29.58    | 0        | 54.41   | 6.32    | 0.12    | 14.34   |
| 4        | 0.618    | 23.14    | 7.43     | 77.55   | 13.75   | 0.18    | 20.44   |
| 5        | 0.824    | 17.46    | 39.75    | 95.01   | 53.5    | 0.56    | 25.05   |
| 6        | 0.879    | 4.39     | 13.77    | 99.4    | 67.27   | 0.68    | 26.20   |
| 7        | 0.949    | 2.02     | 13.89    | 101.42  | 81.16   | 0.80    | 26.74   |
| 8        | 1.192    | 11.46    | 24.97    | 112.88  | 106.13  | 0.94    | 29.76   |
| 9        | 1.468    | 27.99    | 93.68    | 140.87  | 199.81  | 1.42    | 37.14   |
| 10       | 1.721    | 8.53     | 45.81    | 149.4   | 245.62  | 1.64    | 39.38   |
| 11       | 1.836    | 8.61     | 52.61    | 158.01  | 298.23  | 1.89    | 41.65   |
| 12       | 2.154    | 7.25     | 57.5     | 165.26  | 355.73  | 2.15    | 43.56   |
| 13       | 2.306    | 12.84    | 125.56   | 178.1   | 481.29  | 2.70    | 46.95   |
| 14       | 2.660    | 6.05     | 66.22    | 184.15  | 547.51  | 2.97    | 48.54   |
| 15       | 2.794    | 5.48     | 69.3     | 189.63  | 616.81  | 3.25    | 49.99   |
| 16       | 3.004    | 10.18    | 134.37   | 199.81  | 751.18  | 3.76    | 52.67   |

TABLE A-4

TEST NO. 3-01  
INJ TEMP MAX 175 C  
PELICAN LAKE CRUDE  
1 G/L BRINE

STEAM 175 C  
NOM H2O INJ ML/HR 530.0  
OUTLET PRESS PSIG 200/100  
PV ML 422.3  
TOT OIL G 376.6

| SAMPLE # | PV INJ G | OIL PD G | H2O PD G | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|----------|----------|----------|---------|---------|---------|---------|
| 0        | 0        | 0        | 0        | 0       | 0       | 0.00    | 0.00    |
| 1        | 0.27     | 77.89    | 37.42    | 77.89   | 37.42   | 0.48    | 20.68   |
| 2        | 0.64     | 24.14    | 187.35   | 102.03  | 224.77  | 2.20    | 27.09   |
| 3        | 1.28     | 25.01    | 226.13   | 131.04  | 450.9   | 3.44    | 34.60   |
| 4        | 1.79     | 26.7     | 225.69   | 157.74  | 676.59  | 4.29    | 41.69   |
| 5        | 2.25     | 0.69     | 178.58   | 158.43  | 855.17  | 5.40    | 42.07   |
| 6        | 2.68     | 17.47    | 183.5    | 175.9   | 1038.67 | 5.90    | 46.71   |
| 7        | 3.12     | 15.69    | 202.92   | 191.59  | 1241.59 | 6.48    | 50.87   |
| 8        | 3.50     | 12.9     | 127.5    | 204.49  | 1369.09 | 6.70    | 54.30   |
| 9        | 3.68     | 16.24    | 47.32    | 220.73  | 1416.41 | 6.42    | 58.61   |
| 10       | 4.02     | 36.78    | 161.92   | 257.51  | 1578.33 | 6.13    | 68.38   |
| 11       | 4.47     | 30.76    | 216.82   | 288.27  | 1795.15 | 6.23    | 76.55   |

TABLE A-5

TEST NO. 3-02  
INJ TEMP MAX 175 C  
BUFFALO COULEE CRUDE  
1 G/L BRINE

STEAM 175 C  
NOM H2O INJ ML/HR 530.0  
OUTLET PRESS PSIG 350 / 220  
PV ML 424.3  
TOT OIL G 378.7

| SAMPLE # | PV INJ G | OIL PD G | H2O PD G | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|----------|----------|----------|---------|---------|---------|---------|
| 0        | 0        | 0        | 0        | 0       | 0       | 0.00    | 0.00    |
| 1        | 0.28     | 68.69    | 63.6     | 68.69   | 63.6    | 0.93    | 18.14   |
| 2        | 0.56     | 13.85    | 121.26   | 82.54   | 184.86  | 2.24    | 21.80   |
| 3        | 0.88     | 10.22    | 114.13   | 92.76   | 298.99  | 3.22    | 24.49   |
| 4        | 1.32     | 14.39    | 168.54   | 107.15  | 467.53  | 4.36    | 28.29   |
| 5        | 1.74     | 19.09    | 183.89   | 126.24  | 651.42  | 5.16    | 33.34   |
| 6        | 2.05     | 19.18    | 165.66   | 145.42  | 817.08  | 5.62    | 38.40   |
| 7        | 2.55     | 19.52    | 190.83   | 164.94  | 1007.91 | 6.11    | 43.55   |
| 8        | 2.99     | 15.63    | 166.59   | 180.57  | 1174.5  | 6.50    | 47.68   |
| 9        | 3.44     | 19.64    | 181.55   | 200.21  | 1356.05 | 6.77    | 52.87   |
| 10       | 3.89     | 18.62    | 164.15   | 218.83  | 1520.2  | 6.95    | 57.78   |
| 11       | 4.36     | 19.5     | 206.99   | 238.33  | 1727.19 | 7.25    | 62.93   |
| 12       | 4.79     | 17.78    | 218.11   | 256.11  | 1945.3  | 7.60    | 67.63   |

TABLE A-6

TEST NO. 3-03 STEAM 122 C  
INJ TEMP MAX 122 C NOM H2O INJ ML/HR 530.0  
PELICAN LAKE CRUDE OUTLET PRESS PSIG 375 / 150  
1 G/L BRINE PV ML 425  
55 MESH SAND TOT OIL G 383.1

| SAMPLE # | PV   | INJ   | G      | OIL    | PD      | G       | H2O     | PD      | CUM     | OIL   | CUM   | H2O   | CUM   | WOR  | OIL   | REC   |
|----------|------|-------|--------|--------|---------|---------|---------|---------|---------|-------|-------|-------|-------|------|-------|-------|
|          | 0    | 0     | 0      | 0      | 0       | 0       | 0       | 0       | 0       | 0     | 0     | 0     | 0     | 0.00 | 0.00  | 0.00  |
| 1        | 0.39 | 69.61 | 77.91  | 69.61  | 77.91   | 77.91   | 77.91   | 77.91   | 77.91   | 69.61 | 77.91 | 77.91 | 77.91 | 1.12 | 18.17 | 18.17 |
| 2        | 0.73 | 18    | 124.98 | 87.61  | 202.89  | 202.89  | 202.89  | 202.89  | 202.89  | 2.32  | 22.87 | 22.87 | 22.87 | 2.32 | 22.87 | 22.87 |
| 3        | 1.04 | 12.48 | 120.41 | 100.09 | 323.3   | 323.3   | 323.3   | 323.3   | 323.3   | 3.23  | 26.13 | 26.13 | 26.13 | 3.23 | 26.13 | 26.13 |
| 4        | 1.43 | 13.79 | 151.56 | 113.86 | 474.88  | 474.88  | 474.88  | 474.88  | 474.88  | 4.17  | 29.73 | 29.73 | 29.73 | 4.17 | 29.73 | 29.73 |
| 5        | 1.84 | 19.9  | 155.91 | 133.78 | 630.79  | 630.79  | 630.79  | 630.79  | 630.79  | 4.72  | 34.92 | 34.92 | 34.92 | 4.72 | 34.92 | 34.92 |
| 6        | 2.25 | 17.77 | 157.55 | 151.55 | 788.34  | 788.34  | 788.34  | 788.34  | 788.34  | 5.20  | 39.56 | 39.56 | 39.56 | 5.20 | 39.56 | 39.56 |
| 7        | 2.64 | 14    | 151.11 | 165.55 | 939.45  | 939.45  | 939.45  | 939.45  | 939.45  | 5.67  | 43.21 | 43.21 | 43.21 | 5.67 | 43.21 | 43.21 |
| 8        | 3.06 | 12.77 | 163.63 | 178.32 | 1103.08 | 1103.08 | 1103.08 | 1103.08 | 1103.08 | 6.19  | 46.55 | 46.55 | 46.55 | 6.19 | 46.55 | 46.55 |
| 9        | 3.46 | 12.28 | 160.8  | 190.6  | 1263.88 | 1263.88 | 1263.88 | 1263.88 | 1263.88 | 6.63  | 49.75 | 49.75 | 49.75 | 6.63 | 49.75 | 49.75 |
| 10       | 3.89 | 14.7  | 168.82 | 205.3  | 1432.7  | 1432.7  | 1432.7  | 1432.7  | 1432.7  | 6.98  | 53.59 | 53.59 | 53.59 | 6.98 | 53.59 | 53.59 |
| 11       | 4.14 | 8.28  | 97.37  | 213.58 | 1530.07 | 1530.07 | 1530.07 | 1530.07 | 1530.07 | 7.16  | 55.75 | 55.75 | 55.75 | 7.16 | 55.75 | 55.75 |
| 12       | 4.68 | 15.9  | 216.8  | 229.48 | 1746.87 | 1746.87 | 1746.87 | 1746.87 | 1746.87 | 7.61  | 59.90 | 59.90 | 59.90 | 7.61 | 59.90 | 59.90 |
| 13       | 5.01 | 8.12  | 130.82 | 237.6  | 1877.69 | 1877.69 | 1877.69 | 1877.69 | 1877.69 | 7.90  | 62.02 | 62.02 | 62.02 | 7.90 | 62.02 | 62.02 |

TABLE A-7

TEST NO. 3-04 STEAM 121 C  
INJ TEMP MAX 121 C NOM H2O INJ ML/HR 530.0  
BUFFALO COULEE CRUDE OUTLET PRESS PSIG 400 / 150  
1 G/L BRINE PV ML 421.3  
55 MESH SAND TOT OIL G 375.8

| SAMPLE # | PV   | INJ   | G      | OIL    | PD      | G       | H2O     | PD      | CUM     | OIL   | CUM   | H2O   | CUM   | WOR  | OIL   | REC   |
|----------|------|-------|--------|--------|---------|---------|---------|---------|---------|-------|-------|-------|-------|------|-------|-------|
|          | 0    | 0     | 0      | 0      | 0       | 0       | 0       | 0       | 0       | 0     | 0     | 0     | 0     | 0.00 | 0.00  | 0.00  |
| 1        | 0.32 | 67.49 | 75     | 67.49  | 75      | 75      | 75      | 75      | 75      | 67.49 | 75    | 75    | 75    | 1.11 | 17.96 | 17.96 |
| 2        | 0.64 | 17.31 | 119.52 | 84.8   | 194.52  | 194.52  | 194.52  | 194.52  | 194.52  | 2.29  | 22.57 | 22.57 | 22.57 | 2.29 | 22.57 | 22.57 |
| 3        | 2.17 | 12.09 | 128.19 | 96.89  | 322.71  | 322.71  | 322.71  | 322.71  | 322.71  | 3.33  | 25.78 | 25.78 | 25.78 | 3.33 | 25.78 | 25.78 |
| 4        | 1.31 | 14.54 | 124.77 | 111.43 | 447.48  | 447.48  | 447.48  | 447.48  | 447.48  | 4.02  | 29.65 | 29.65 | 29.65 | 4.02 | 29.65 | 29.65 |
| 5        | 1.62 | 14.01 | 117.02 | 125.44 | 564.5   | 564.5   | 564.5   | 564.5   | 564.5   | 4.50  | 33.38 | 33.38 | 33.38 | 4.50 | 33.38 | 33.38 |
| 6        | 2.06 | 18.69 | 168.81 | 144.13 | 733.31  | 733.31  | 733.31  | 733.31  | 733.31  | 5.09  | 38.35 | 38.35 | 38.35 | 5.09 | 38.35 | 38.35 |
| 7        | 2.50 | 13.25 | 166.83 | 157.38 | 900.14  | 900.14  | 900.14  | 900.14  | 900.14  | 5.72  | 41.88 | 41.88 | 41.88 | 5.72 | 41.88 | 41.88 |
| 8        | 2.94 | 15.42 | 171.47 | 172.8  | 1071.61 | 1071.61 | 1071.61 | 1071.61 | 1071.61 | 6.20  | 45.98 | 45.98 | 45.98 | 6.20 | 45.98 | 45.98 |
| 9        | 3.35 | 14.09 | 158.95 | 186.89 | 1230.56 | 1230.56 | 1230.56 | 1230.56 | 1230.56 | 6.58  | 49.73 | 49.73 | 49.73 | 6.58 | 49.73 | 49.73 |
| 10       | 3.95 | 20.07 | 234.58 | 206.96 | 1465.14 | 1465.14 | 1465.14 | 1465.14 | 1465.14 | 7.08  | 55.07 | 55.07 | 55.07 | 7.08 | 55.07 | 55.07 |
| 11       | 4.48 | 16.64 | 205.88 | 223.6  | 1671.02 | 1671.02 | 1671.02 | 1671.02 | 1671.02 | 7.47  | 59.50 | 59.50 | 59.50 | 7.47 | 59.50 | 59.50 |
| 12       | 5.02 | 16.25 | 213.16 | 239.85 | 1884.18 | 1884.18 | 1884.18 | 1884.18 | 1884.18 | 7.86  | 63.82 | 63.82 | 63.82 | 7.86 | 63.82 | 63.82 |

TABLE A-8

TEST NO. 4-1  
INJ TEMP 100C  
PELICAN LAKE CRUDE  
5 G/L BRINE  
55 MESH SAND

TABLE A-9

TEST NO. 4-2  
INJ TEMP MAX 134 C  
PELICAN LAKE CRUDE  
5 G/L BRINE  
55 MESH SAND

ML LWR 36

ML LWR 36

| SAMPLE # | HOT WATER + N2 |       |       |        | HOT WATER + N2 |      |      |      | HOT WATER + N2 |      |       |      | HOT WATER + N2 |      |       |      | HOT WATER + N2 |      |       |      |
|----------|----------------|-------|-------|--------|----------------|------|------|------|----------------|------|-------|------|----------------|------|-------|------|----------------|------|-------|------|
|          | PV             | INJ   | G     | OIL    | PD             | G    | N2O  | PD   | CUM            | OIL  | PD    | G    | N2O            | PD   | CUM   | OIL  | PD             | G    | N2O   | PD   |
| 1        | 0.135          | 29.58 | 5.82  | 29.58  | 0              | 0    | 0    | 0    | 0.00           | 0.00 | 0.00  | 0.00 | 0.00           | 0.00 | 0.00  | 0.00 | 0.00           | 0.00 | 0.00  | 0.00 |
| 2        | 0.312          | 30.2  | 37.37 | 59.78  | 43.19          | 5.82 | 5.82 | 0.20 | 7.91           | 0.20 | 7.91  | 0.20 | 7.91           | 0.20 | 7.91  | 0.20 | 7.91           | 0.20 | 7.91  | 0.20 |
| 3        | 0.52           | 17.07 | 64.94 | 76.65  | 108.13         | 1.41 | 1.41 | 0.72 | 15.99          | 0.72 | 15.99 | 0.72 | 15.99          | 0.72 | 15.99 | 0.72 | 15.99          | 0.72 | 15.99 | 0.72 |
| 4        | 0.936          | 11.67 | 70.27 | 88.52  | 176.4          | 2.02 | 2.02 | 1.41 | 20.56          | 1.41 | 20.56 | 1.41 | 20.56          | 1.41 | 20.56 | 1.41 | 20.56          | 1.41 | 20.56 | 1.41 |
| 5        | 1.135          | 8.2   | 73.56 | 98.02  | 251.98         | 2.57 | 2.57 | 2.02 | 23.68          | 2.02 | 23.68 | 2.02 | 23.68          | 2.02 | 23.68 | 2.02 | 23.68          | 2.02 | 23.68 | 2.02 |
| 6        | 1.303          | 7.5   | 74.48 | 106.22 | 326.46         | 3.07 | 3.07 | 2.57 | 26.22          | 2.57 | 26.22 | 2.57 | 26.22          | 2.57 | 26.22 | 2.57 | 26.22          | 2.57 | 26.22 | 2.57 |
| 7        | 1.575          | 7.57  | 75.94 | 113.72 | 402.4          | 3.54 | 3.54 | 3.07 | 28.42          | 3.07 | 28.42 | 3.07 | 28.42          | 3.07 | 28.42 | 3.07 | 28.42          | 3.07 | 28.42 | 3.07 |
| 8        | 1.79           | 5.55  | 76.73 | 121.29 | 477.06         | 3.93 | 3.93 | 3.54 | 30.42          | 3.54 | 30.42 | 3.54 | 30.42          | 3.54 | 30.42 | 3.54 | 30.42          | 3.54 | 30.42 | 3.54 |
| 9        | 2.217          | 5.71  | 77.44 | 127.24 | 553.79         | 4.35 | 4.35 | 3.93 | 32.45          | 3.93 | 32.45 | 3.93 | 32.45          | 3.93 | 32.45 | 3.93 | 32.45          | 3.93 | 32.45 | 3.93 |
| 10       | 2.425          | 5.26  | 74.36 | 132.95 | 631.23         | 4.75 | 4.75 | 4.35 | 34.04          | 4.35 | 34.04 | 4.35 | 34.04          | 4.35 | 34.04 | 4.35 | 34.04          | 4.35 | 34.04 | 4.35 |
| 11       | 2.621          | 5.38  | 74.37 | 143.59 | 779.96         | 5.11 | 5.11 | 4.75 | 35.57          | 4.75 | 35.57 | 4.75 | 35.57          | 4.75 | 35.57 | 4.75 | 35.57          | 4.75 | 35.57 | 4.75 |
| 12       | 2.824          | 4.46  | 66.87 | 158.15 | 919.95         | 5.82 | 5.82 | 5.11 | 36.97          | 5.11 | 36.97 | 5.11 | 36.97          | 5.11 | 36.97 | 5.11 | 36.97          | 5.11 | 36.97 | 5.11 |
| 13       | 3.039          | 4.9   | 78.54 | 163.05 | 998.49         | 6.12 | 6.12 | 5.82 | 38.41          | 5.82 | 38.41 | 5.82 | 38.41          | 5.82 | 38.41 | 5.82 | 38.41          | 5.82 | 38.41 | 5.82 |
| 14       | 3.261          | 7.22  | 75.82 | 170.27 | 1074.31        | 6.31 | 6.31 | 6.12 | 43.62          | 6.12 | 43.62 | 6.12 | 43.62          | 6.12 | 43.62 | 6.12 | 43.62          | 6.12 | 43.62 | 6.12 |
| 15       | 3.566          | 3.28  | 96.87 | 173.55 | 1171.18        | 6.75 | 6.75 | 6.31 | 45.55          | 6.31 | 45.55 | 6.31 | 45.55          | 6.31 | 45.55 | 6.31 | 45.55          | 6.31 | 45.55 | 6.31 |
| 16       | 3.83           | 5.11  | 88.89 | 178.66 | 1260.07        | 7.05 | 7.05 | 6.75 | 46.43          | 6.75 | 46.43 | 6.75 | 46.43          | 6.75 | 46.43 | 6.75 | 46.43          | 6.75 | 46.43 | 6.75 |
| 17       | 4.098          | 5.93  | 95.94 | 184.59 | 1356.01        | 7.35 | 7.35 | 7.05 | 47.80          | 7.05 | 47.80 | 7.05 | 47.80          | 7.05 | 47.80 | 7.05 | 47.80          | 7.05 | 47.80 | 7.05 |
| 18       | 4.311          | 5.06  | 81.88 | 189.55 | 1437.89        | 7.58 | 7.58 | 7.35 | 49.38          | 7.35 | 49.38 | 7.35 | 49.38          | 7.35 | 49.38 | 7.35 | 49.38          | 7.35 | 49.38 | 7.35 |
| 19       | 4.56           | 1.03  | 29.88 | 190.68 | 1467.77        | 7.70 | 7.70 | 7.58 | 50.74          | 7.58 | 50.74 | 7.58 | 50.74          | 7.58 | 50.74 | 7.58 | 50.74          | 7.58 | 50.74 | 7.58 |
| 20       | 4.81           | 2.56  | 23.19 | 193.24 | 1490.96        | 7.72 | 7.72 | 7.70 | 51.01          | 7.70 | 51.01 | 7.70 | 51.01          | 7.70 | 51.01 | 7.70 | 51.01          | 7.70 | 51.01 | 7.70 |
| 21       | 5.06           | 8.34  | 20.6  | 201.58 | 1511.56        | 7.50 | 7.50 | 7.72 | 51.70          | 7.72 | 51.70 | 7.72 | 51.70          | 7.72 | 51.70 | 7.72 | 51.70          | 7.72 | 51.70 | 7.72 |
| 22       | 5.28           | 8.28  | 21.35 | 209.86 | 1532.91        | 7.30 | 7.30 | 7.50 | 53.93          | 7.50 | 53.93 | 7.50 | 53.93          | 7.50 | 53.93 | 7.50 | 53.93          | 7.50 | 53.93 | 7.50 |
| 23       | 5.45           | 5.85  | 9.06  | 215.71 | 1541.97        | 7.15 | 7.15 | 7.30 | 56.14          | 7.30 | 56.14 | 7.30 | 56.14          | 7.30 | 56.14 | 7.30 | 56.14          | 7.30 | 56.14 | 7.30 |
| 24       |                |       |       |        |                |      |      |      |                |      |       |      |                |      |       |      |                |      |       |      |
| 25       |                |       |       |        |                |      |      |      |                |      |       |      |                |      |       |      |                |      |       |      |
| CUM      |                |       |       |        |                |      |      |      |                |      |       |      |                |      |       |      |                |      |       |      |
| WOR      |                |       |       |        |                |      |      |      |                |      |       |      |                |      |       |      |                |      |       |      |
| OIL      |                |       |       |        |                |      |      |      |                |      |       |      |                |      |       |      |                |      |       |      |
| REC      |                |       |       |        |                |      |      |      |                |      |       |      |                |      |       |      |                |      |       |      |

TABLE A-10

TEST NO. 4-3  
INJ TEMP MAX 125 C  
PELICAN LAKE CRUDE  
5 G/L BRINE  
55 MESH SAND

( HOT WATER + N2 )  
AVG H2O INJ ML/HR  
OUTLET PRESS PSIG  
PV ML  
TOT OIL G

689

200  
419.7  
364.2

| SAMPLE # | PV   | INJ   | G OIL  | PD     | G H2O   | PD   | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|------|-------|--------|--------|---------|------|---------|---------|---------|---------|
| 0        | 0    | 0     | 0      | 0      | 0       | 0    | 0       | 0       | 0.00    | 0.00    |
| 1        | 0.32 | 56.73 | 44.55  | 56.73  | 44.55   | 0.79 | 15.58   | 0.79    | 15.58   | 0.00    |
| 2        | 0.74 | 26.03 | 135.28 | 82.76  | 179.83  | 2.17 | 22.72   | 2.17    | 22.72   | 0.00    |
| 3        | 1.19 | 20.18 | 219.28 | 102.94 | 399.11  | 3.86 | 28.26   | 3.86    | 28.26   | 0.00    |
| 4        | 1.43 | 14.15 | 188.8  | 117.09 | 587.91  | 5.02 | 32.15   | 5.02    | 32.15   | 0.00    |
| 5        | 2.19 | 10.04 | 119.92 | 127.13 | 707.83  | 5.57 | 34.91   | 5.57    | 34.91   | 0.00    |
| 6        | 2.59 | 6.44  | 92.66  | 133.57 | 800.49  | 5.99 | 36.67   | 5.99    | 36.67   | 0.00    |
| 7        | 2.92 | 7.58  | 117    | 141.15 | 917.49  | 6.50 | 38.76   | 6.50    | 38.76   | 0.00    |
| 8        | 3.26 | 4.75  | 128.65 | 145.9  | 1046.14 | 7.17 | 40.06   | 7.17    | 40.06   | 0.00    |
| 9        | 3.63 | 3.9   | 127.6  | 149.8  | 1173.74 | 7.84 | 41.13   | 7.84    | 41.13   | 0.00    |
| 10       | 4.03 | 4.42  | 150.28 | 154.22 | 1324.02 | 8.59 | 42.34   | 8.59    | 42.34   | 0.00    |
| 11       | 4.38 | 28.15 | 113.93 | 182.37 | 1437.95 | 7.88 | 50.07   | 7.88    | 50.07   | 0.00    |
| 12       |      | 6.81  | 78.36  | 189.18 | 1516.31 | 8.02 | 51.94   | 8.02    | 51.94   | 0.00    |
| 13       |      | 27.32 | 39.81  | 216.5  | 1556.12 | 7.19 | 59.45   | 7.19    | 59.45   | 0.00    |
| 14       |      | 11.77 | 0.5    | 228.27 | 1556.62 | 6.82 | 62.68   | 6.82    | 62.68   | 0.00    |

TABLE A-11

TEST NO. 4-4  
INJ TEMP MAX 125 C  
PELICAN LAKE CRUDE  
5 G/L BRINE  
55 MESH SAND

( HOT WATER + N2 )  
AVG H2O INJ ML/HR  
OUTLET PRESS PSIG  
PV ML  
TOT OIL G

1580  
200  
424.3  
369.2

| SAMPLE # | PV   | INJ   | G OIL  | PD     | G H2O   | PD   | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|------|-------|--------|--------|---------|------|---------|---------|---------|---------|
| 0        | 0    | 0     | 0      | 0      | 0       | 0    | 0       | 0       | 0.00    | 0.00    |
| 1        | 0.59 | 74.71 | 143.48 | 74.71  | 143.48  | 1.92 | 20.24   | 1.92    | 20.24   | 0.00    |
| 2        | 1.15 | 22.41 | 212.45 | 97.12  | 355.93  | 3.66 | 26.31   | 3.66    | 26.31   | 0.00    |
| 3        | 1.70 | 15.19 | 223.06 | 112.31 | 578.99  | 5.16 | 30.42   | 5.16    | 30.42   | 0.00    |
| 4        | 2.28 | 14.85 | 216.76 | 127.16 | 795.75  | 6.26 | 34.44   | 6.26    | 34.44   | 0.00    |
| 5        | 2.86 | 12.12 | 227.28 | 139.28 | 1023.03 | 7.35 | 37.72   | 7.35    | 37.72   | 0.00    |
| 6        | 3.44 | 20.9  | 222    | 160.18 | 1245.03 | 7.77 | 43.39   | 7.77    | 43.39   | 0.00    |
| 7        | 4.02 | 14.77 | 230    | 174.95 | 1475.03 | 8.43 | 47.39   | 8.43    | 47.39   | 0.00    |
| 8        |      | 1.87  | 77.29  | 176.82 | 1552.32 | 8.78 | 47.89   | 8.78    | 47.89   | 0.00    |
| 9        |      | 19.25 | 14.22  | 196.07 | 1566.54 | 7.99 | 53.11   | 7.99    | 53.11   | 0.00    |
| 10       |      | 25.91 | 25.24  | 221.98 | 1591.78 | 7.17 | 60.12   | 7.17    | 60.12   | 0.00    |
| 11       |      | 4.72  | 0.6    | 226.7  | 1592.38 | 7.02 | 61.40   | 7.02    | 61.40   | 0.00    |
| 12       |      | 3.99  | 0.1    | 230.69 | 1592.48 | 6.90 | 62.48   | 6.90    | 62.48   | 0.00    |

TABLE A-12

TEST NO. 4-5 [ HOT WATER + N2 ]  
 INJ TEMP MAX 106 C NOM H2O INJ ML/HR  
 PELICAN LAKE CRUDE OUTLET PRESS PSIG  
 5 G/L BRINE PV ML  
 55 MESH SAND TOT OIL G

| SAMPLE # | PV   | INJ   | G      | OIL    | PD      | G     | H2O    | PD    | CUM   | OIL   | CUM   | N2O   | CUM   | WOR  | OIL   | REC   |
|----------|------|-------|--------|--------|---------|-------|--------|-------|-------|-------|-------|-------|-------|------|-------|-------|
|          | 0    | 0     | 0      | 0      | 0       | 0     | 0      | 0     | 0     | 0     | 0     | 0     | 0     | 0.00 | 0.00  | 0.00  |
| 1        | 0.33 | 57.75 | 47.73  | 57.75  | 47.73   | 57.75 | 47.73  | 57.75 | 47.73 | 57.75 | 47.73 | 57.75 | 47.73 | 0.83 | 16.13 | 16.13 |
| 2        | 0.68 | 20.13 | 102.96 | 77.88  | 102.96  | 77.88 | 150.69 | 1.93  | 21.75 | 21.75 | 21.75 | 21.75 | 21.75 | 2.86 | 25.18 | 25.18 |
| 3        | 1.01 | 12.29 | 107.26 | 90.17  | 257.95  | 2.86  | 25.18  | 3.58  | 27.69 | 27.69 | 27.69 | 27.69 | 27.69 | 4.25 | 30.54 | 30.54 |
| 4        | 1.32 | 8.99  | 97.15  | 99.16  | 355.1   | 3.58  | 27.69  | 4.92  | 32.92 | 32.92 | 32.92 | 32.92 | 32.92 | 5.51 | 35.34 | 35.34 |
| 5        | 1.65 | 10.22 | 109.79 | 109.38 | 464.89  | 4.25  | 30.54  | 5.98  | 37.39 | 37.39 | 37.39 | 37.39 | 37.39 | 5.86 | 41.70 | 41.70 |
| 6        | 2.00 | 8.51  | 115.2  | 117.89 | 580.09  | 4.92  | 32.92  | 6.39  | 43.70 | 43.70 | 43.70 | 43.70 | 43.70 | 6.39 | 43.70 | 43.70 |
| 7        | 2.35 | 8.68  | 117.47 | 126.57 | 697.56  | 5.51  | 35.34  | 6.95  | 45.96 | 45.96 | 45.96 | 45.96 | 45.96 | 6.78 | 51.30 | 51.30 |
| 8        | 2.66 | 7.31  | 102.38 | 133.88 | 799.94  | 5.98  | 37.39  | 7.09  | 53.74 | 53.74 | 53.74 | 53.74 | 53.74 | 7.34 | 54.91 | 54.91 |
| 9        | 2.93 | 15.44 | 75.68  | 149.32 | 875.62  | 5.86  | 41.70  | 6.74  | 61.59 | 61.59 | 61.59 | 61.59 | 61.59 | 6.62 | 62.82 | 62.82 |
| 10       | 3.30 | 7.18  | 124.68 | 156.5  | 1000.3  | 6.39  | 43.70  | 6.95  | 45.96 | 45.96 | 45.96 | 45.96 | 45.96 | 6.78 | 51.30 | 51.30 |
| 11       | 3.71 | 8.07  | 143.72 | 164.57 | 1144.02 | 6.95  | 45.96  | 7.09  | 53.74 | 53.74 | 53.74 | 53.74 | 53.74 | 7.34 | 54.91 | 54.91 |
| 12       | 4.07 | 19.15 | 102.22 | 183.72 | 1246.24 | 6.78  | 51.30  | 6.62  | 62.82 | 62.82 | 62.82 | 62.82 | 62.82 | 6.62 | 62.82 | 62.82 |
| 13       | 4.42 | 8.74  | 118.89 | 192.46 | 1365.13 | 7.09  | 53.74  | 7.34  | 54.91 | 54.91 | 54.91 | 54.91 | 54.91 | 7.34 | 54.91 | 54.91 |
| 14       |      | 4.16  | 78.86  | 196.62 | 1463.99 | 7.34  | 54.91  | 6.62  | 62.82 | 62.82 | 62.82 | 62.82 | 62.82 | 6.62 | 62.82 | 62.82 |
| 15       |      | 23.93 | 41.71  | 220.55 | 1485.7  | 6.74  | 61.59  | 6.62  | 62.82 | 62.82 | 62.82 | 62.82 | 62.82 | 6.62 | 62.82 | 62.82 |
| 16       |      | 4.42  | 3.56   | 224.97 | 1489.26 | 6.62  | 62.82  | 6.62  | 62.82 | 62.82 | 62.82 | 62.82 | 62.82 | 6.62 | 62.82 | 62.82 |

TABLE A-13

TEST NO. 4-6 [ HOT WATER + N2 ]  
 INJ TEMP MAX 105 C NOM H2O INJ ML/HR  
 PELICAN LAKE CRUDE OUTLET PRESS PSIG  
 5 G/L BRINE PV ML  
 55 MESH SAND TOT OIL G

| SAMPLE # | PV    | INJ   | G      | OIL     | PD      | G     | H2O    | PD    | CUM    | OIL   | CUM    | N2O   | CUM    | WOR  | OIL   | REC   |
|----------|-------|-------|--------|---------|---------|-------|--------|-------|--------|-------|--------|-------|--------|------|-------|-------|
|          | 0     | 0     | 0      | 0       | 0       | 0     | 0      | 0     | 0      | 0     | 0      | 0     | 0      | 0.00 | 0.00  | 0.00  |
| 1        | 0.66  | 80.35 | 178.65 | 80.35   | 178.65  | 80.35 | 178.65 | 80.35 | 178.65 | 80.35 | 178.65 | 80.35 | 178.65 | 2.22 | 21.87 | 21.87 |
| 2        | 1.22  | 21.97 | 210.72 | 102.32  | 309.37  | 3.81  | 27.85  | 5.16  | 31.78  | 31.78 | 31.78  | 31.78 | 31.78  | 6.23 | 35.78 | 35.78 |
| 3        | 1.78  | 14.45 | 213.23 | 116.77  | 602.6   | 7.11  | 39.64  | 7.92  | 43.09  | 43.09 | 43.09  | 43.09 | 43.09  | 8.64 | 46.39 | 46.39 |
| 4        | 2.32  | 14.67 | 216.14 | 131.44  | 818.74  | 8.64  | 46.39  | 9.32  | 49.81  | 49.81 | 49.81  | 49.81 | 49.81  | 9.03 | 54.15 | 54.15 |
| 5        | 2.88  | 14.2  | 216.04 | 145.64  | 1034.78 | 9.32  | 49.81  | 9.03  | 54.15  | 54.15 | 54.15  | 54.15 | 54.15  | 8.46 | 58.89 | 58.89 |
| 6        | 3.44  | 12.67 | 219.07 | 158.31  | 1253.85 | 8.46  | 58.89  | 8.31  | 59.94  | 59.94 | 59.94  | 59.94 | 59.94  | 8.31 | 59.94 | 59.94 |
| 7        | 3.98  | 12.11 | 219.42 | 170.42  | 1473.27 | 8.64  | 46.39  | 9.32  | 49.81  | 49.81 | 49.81  | 49.81 | 49.81  | 9.03 | 54.15 | 54.15 |
| 8        | 4.59  | 12.57 | 231.75 | 182.99  | 1705.02 | 9.32  | 49.81  | 9.03  | 54.15  | 54.15 | 54.15  | 54.15 | 54.15  | 8.46 | 58.89 | 58.89 |
| 9        | 15.94 | 91.75 | 198.93 | 1796.77 | 1829.41 | 8.46  | 58.89  | 8.31  | 59.94  | 59.94 | 59.94  | 59.94 | 59.94  | 8.31 | 59.94 | 59.94 |
| 10       | 17.44 | 32.64 | 216.37 | 1829.41 | 1829.41 | 8.46  | 58.89  | 8.31  | 59.94  | 59.94 | 59.94  | 59.94 | 59.94  | 8.31 | 59.94 | 59.94 |
| 11       | 3.86  | 1.7   | 220.23 | 1831.11 | 1831.11 | 8.46  | 58.89  | 8.31  | 59.94  | 59.94 | 59.94  | 59.94 | 59.94  | 8.31 | 59.94 | 59.94 |

TABLE A-14

TEST NO. 4-7 [ HOT WATER + N2 ]  
 INJ TEMP MAX 109 C  
 PELICAN LAKE CRUDE  
 5 G/L BRINE  
 55 MESH SAND

TEST NO. 4-8 [ HOT WATER + N2 ]  
 INJ TEMP MAX 112 C  
 PELICAN LAKE CRUDE  
 5 G/L BRINE  
 55 MESH SAND

530 NOM N2 L/HR  
 100  
 418.1  
 358.8

1530.0 NOM N2 L/HR  
 100  
 433.9  
 366

| SAMPLE # | PV INJ | G OIL | PD G   | H2O PD  | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|--------|-------|--------|---------|---------|---------|---------|---------|
| 0        | 0      | 0     | 0      | 0       | 0       | 0       | 0.00    | 0.00    |
| 1        | 0.46   | 68.29 | 97.18  | 68.29   | 68.29   | 97.18   | 1.42    | 19.03   |
| 2        | 0.80   | 18.39 | 108.56 | 86.68   | 205.74  | 205.74  | 2.37    | 24.16   |
| 3        | 1.25   | 17.28 | 152.58 | 103.96  | 358.32  | 358.32  | 3.45    | 28.97   |
| 4        | 1.70   | 15.13 | 156.24 | 119.09  | 514.56  | 514.56  | 4.32    | 33.19   |
| 5        | 2.15   | 11.52 | 159.98 | 130.61  | 674.54  | 674.54  | 5.16    | 36.40   |
| 6        | 2.61   | 12.34 | 157.77 | 142.95  | 832.31  | 832.31  | 5.82    | 39.84   |
| 7        | 3.08   | 10.6  | 165.17 | 153.55  | 997.48  | 997.48  | 6.50    | 42.80   |
| 8        | 3.49   | 10.19 | 169.67 | 163.74  | 1167.15 | 1167.15 | 7.13    | 45.64   |
| 9        | 4.10   | 11.34 | 214.31 | 175.08  | 1381.46 | 1381.46 | 7.89    | 48.80   |
| 10       | 6.24   | 97.94 | 181.32 | 1479.4  | 1479.4  | 1479.4  | 8.16    | 50.54   |
| 11       | 42.1   | 28.87 | 223.42 | 1508.27 | 1508.27 | 1508.27 | 6.75    | 62.27   |
| 12       | 12.07  | 1.14  | 235.49 | 1509.41 | 1509.41 | 1509.41 | 6.41    | 65.63   |

| SAMPLE # | PV INJ | G OIL | PD G   | H2O PD  | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|--------|-------|--------|---------|---------|---------|---------|---------|
| 0        | 0      | 0     | 0      | 0       | 0       | 0       | 0.00    | 0.00    |
| 1        | 0.22   | 52.29 | 5.27   | 52.29   | 52.29   | 5.27    | 0.10    | 14.29   |
| 2        | 0.83   | 34.62 | 212.84 | 86.91   | 218.11  | 218.11  | 2.51    | 23.75   |
| 3        | 1.39   | 19.87 | 216.07 | 106.78  | 434.18  | 434.18  | 4.07    | 29.17   |
| 4        | 2.00   | 18.18 | 234.97 | 124.96  | 669.15  | 669.15  | 5.35    | 34.14   |
| 5        | 2.59   | 18.59 | 225.37 | 143.55  | 894.52  | 894.52  | 6.23    | 39.22   |
| 6        | 3.19   | 15.59 | 234.67 | 159.14  | 1129.19 | 1129.19 | 7.10    | 43.48   |
| 7        | 3.80   | 15.73 | 241.73 | 174.87  | 1370.92 | 1370.92 | 7.84    | 47.78   |
| 8        | 4.41   | 15.53 | 241.08 | 190.4   | 1612    | 1612    | 8.47    | 52.02   |
| 9        | 5.66   | 91.52 | 196.06 | 1703.52 | 1703.52 | 1703.52 | 8.69    | 53.57   |
| 10       | 32.6   | 42.45 | 228.66 | 1745.97 | 1745.97 | 1745.97 | 7.64    | 62.48   |
| 11       | 19.65  | 2.9   | 248.31 | 1748.87 | 1748.87 | 1748.87 | 7.04    | 67.84   |

TABLE A-16

| TEST NO. 4-9<br>INJ TEMP MAX 154 C<br>PELICAN LAKE CRUDE<br>5 G/L BRINE<br>55 MESH SAND |      |       |        |        |         |      |       |      |       | [ HOT WATER + N2 ]<br>NOM H2O INJ 530.0 NOM N2 L/ 32.25<br>OUTLET PRESS PSIG 200<br>PV ML 423.1<br>TOT OIL G 362.8 |       |         |         |      |       |      |  |  |  |
|-----------------------------------------------------------------------------------------|------|-------|--------|--------|---------|------|-------|------|-------|--------------------------------------------------------------------------------------------------------------------|-------|---------|---------|------|-------|------|--|--|--|
| SAMPLE #                                                                                | PV   | INJ   | G      | OIL    | PD      | G    | H2O   | PD   | CUM   | OIL                                                                                                                | CUM   | H2O     | CUM     | WOR  | OIL   | REC  |  |  |  |
| 1                                                                                       | 0.47 | 68.17 | 106.76 | 68.17  | 106.76  | 0    | 0     | 0    | 0     | 0.00                                                                                                               | 0.00  | 0       | 0.00    | 0.00 | 0.00  | 0.00 |  |  |  |
| 2                                                                                       | 0.83 | 13.96 | 122.4  | 82.13  | 229.16  | 2.79 | 22.64 | 2.79 | 22.64 | 2.79                                                                                                               | 22.64 | 3.80    | 25.65   | 3.80 | 25.65 | 3.80 |  |  |  |
| 3                                                                                       | 1.19 | 10.94 | 124.75 | 93.07  | 353.91  | 4.98 | 28.92 | 4.98 | 28.92 | 4.98                                                                                                               | 28.92 | 5.98    | 32.38   | 5.98 | 32.38 | 5.98 |  |  |  |
| 4                                                                                       | 1.66 | 11.85 | 168.51 | 104.92 | 522.42  | 6.85 | 36.12 | 6.85 | 36.12 | 6.85                                                                                                               | 36.12 | 7.61    | 38.36   | 7.61 | 38.36 | 7.61 |  |  |  |
| 5                                                                                       | 2.16 | 12.54 | 179.57 | 117.46 | 701.99  | 8.36 | 40.62 | 8.36 | 40.62 | 8.36                                                                                                               | 40.62 | 8.75    | 43.37   | 8.75 | 43.37 | 8.75 |  |  |  |
| 6                                                                                       | 2.61 | 13.6  | 196.04 | 131.06 | 898.03  | 8.51 | 46.93 | 8.51 | 46.93 | 8.51                                                                                                               | 46.93 | 7.30    | 55.66   | 7.30 | 55.66 | 7.30 |  |  |  |
| 7                                                                                       | 3.09 | 8.11  | 160.82 | 139.17 | 1058.85 | 7.04 | 57.87 | 7.04 | 57.87 | 7.04                                                                                                               | 57.87 | 1478.15 | 1478.15 | 7.04 | 57.87 | 7.04 |  |  |  |
| 8                                                                                       | 3.62 | 8.21  | 172.64 | 147.38 | 1231.49 | 8.36 | 40.62 | 8.36 | 40.62 | 8.36                                                                                                               | 40.62 | 1231.49 | 1231.49 | 8.36 | 40.62 | 8.36 |  |  |  |
| 9                                                                                       | 4.01 | 9.97  | 145.3  | 157.35 | 1376.79 | 8.75 | 43.37 | 8.75 | 43.37 | 8.75                                                                                                               | 43.37 | 1376.79 | 1376.79 | 8.75 | 43.37 | 8.75 |  |  |  |
| 10                                                                                      |      | 12.9  | 71.44  | 170.25 | 1448.23 | 8.51 | 46.93 | 8.51 | 46.93 | 8.51                                                                                                               | 46.93 | 1448.23 | 1448.23 | 8.51 | 46.93 | 8.51 |  |  |  |
| 11                                                                                      |      | 31.68 | 26.17  | 201.93 | 1474.4  | 7.30 | 55.66 | 7.30 | 55.66 | 7.30                                                                                                               | 55.66 | 1474.4  | 1474.4  | 7.30 | 55.66 | 7.30 |  |  |  |
| 12                                                                                      |      | 8.02  | 3.75   | 209.95 | 1478.15 | 7.04 | 57.87 | 7.04 | 57.87 | 7.04                                                                                                               | 57.87 | 1478.15 | 1478.15 | 7.04 | 57.87 | 7.04 |  |  |  |

TABLE A-17

| TEST NO. 4-10<br>INJ TEMP MAX 1504 C<br>PELICAN LAKE CRUDE<br>5 G/L BRINE<br>55 MESH SAND |      |       |        |        |         |      |       |      |       | [ HOT WATER + N2 ]<br>NOM H2O INJ 1530.0 N2 L/HR<br>OUTLET PRESS PSIG 200<br>PV ML 423.5<br>TOT OIL G 365.6 |       |         |         |      |       |      |  |  |  |
|-------------------------------------------------------------------------------------------|------|-------|--------|--------|---------|------|-------|------|-------|-------------------------------------------------------------------------------------------------------------|-------|---------|---------|------|-------|------|--|--|--|
| SAMPLE #                                                                                  | PV   | INJ   | G      | OIL    | PD      | G    | H2O   | PD   | CUM   | OIL                                                                                                         | CUM   | H2O     | CUM     | WOR  | OIL   | REC  |  |  |  |
| 1                                                                                         | 0.70 | 73.29 | 153.9  | 73.29  | 153.9   | 0    | 0     | 0    | 0     | 0.00                                                                                                        | 0.00  | 0       | 0.00    | 0.00 | 0.00  | 0.00 |  |  |  |
| 2                                                                                         | 1.31 | 20.96 | 231.35 | 94.25  | 383.25  | 4.07 | 25.78 | 4.07 | 25.78 | 4.07                                                                                                        | 25.78 | 596.21  | 596.21  | 4.07 | 25.78 | 4.07 |  |  |  |
| 3                                                                                         | 1.87 | 20.32 | 212.96 | 114.57 | 793.82  | 6.08 | 35.73 | 6.08 | 35.73 | 6.08                                                                                                        | 35.73 | 793.82  | 793.82  | 6.08 | 35.73 | 6.08 |  |  |  |
| 4                                                                                         | 2.38 | 16.07 | 197.61 | 130.64 | 985.46  | 6.78 | 39.73 | 6.78 | 39.73 | 6.78                                                                                                        | 39.73 | 985.46  | 985.46  | 6.78 | 39.73 | 6.78 |  |  |  |
| 5                                                                                         | 2.87 | 14.62 | 191.64 | 145.26 | 1171.69 | 7.44 | 43.10 | 7.44 | 43.10 | 7.44                                                                                                        | 43.10 | 1171.69 | 1171.69 | 7.44 | 43.10 | 7.44 |  |  |  |
| 6                                                                                         | 3.36 | 12.3  | 186.23 | 157.56 | 1348.18 | 7.94 | 46.47 | 7.94 | 46.47 | 7.94                                                                                                        | 46.47 | 1348.18 | 1348.18 | 7.94 | 46.47 | 7.94 |  |  |  |
| 7                                                                                         | 3.80 | 12.34 | 176.49 | 169.9  | 1538.02 | 8.46 | 49.72 | 8.46 | 49.72 | 8.46                                                                                                        | 49.72 | 1538.02 | 1538.02 | 8.46 | 49.72 | 8.46 |  |  |  |
| 8                                                                                         | 4.29 | 11.88 | 189.84 | 181.78 | 1620.42 | 8.69 | 51.01 | 8.69 | 51.01 | 8.69                                                                                                        | 51.01 | 1620.42 | 1620.42 | 8.69 | 51.01 | 8.69 |  |  |  |
| 9                                                                                         |      | 4.7   | 82.4   | 186.48 | 1658.39 | 7.56 | 60.01 | 7.56 | 60.01 | 7.56                                                                                                        | 60.01 | 1658.39 | 1658.39 | 7.56 | 60.01 | 7.56 |  |  |  |
| 10                                                                                        |      | 32.93 | 37.97  | 219.41 | 1664.89 | 7.39 | 61.58 | 7.39 | 61.58 | 7.39                                                                                                        | 61.58 | 1664.89 | 1664.89 | 7.39 | 61.58 | 7.39 |  |  |  |
| 11                                                                                        |      | 5.74  | 6.5    | 225.15 |         |      |       |      |       |                                                                                                             |       |         |         |      |       |      |  |  |  |

TABLE A-18

| TEST NO. 4-11 ( HOT WATER + N2 ) |          |          |        |         |         |         |         |      |      |
|----------------------------------|----------|----------|--------|---------|---------|---------|---------|------|------|
| INJ TEMP MAX 134 C               |          |          |        |         |         |         |         |      |      |
| PELICAN LAKE CRUDE               |          |          |        |         |         |         |         |      |      |
| 5 G/L BRINE                      |          |          |        |         |         |         |         |      |      |
| 55 MESH SAND                     |          |          |        |         |         |         |         |      |      |
| NOM H2O INJ ML/HR                |          |          |        |         |         |         |         |      |      |
| OUTLET PRESS PSIG                |          |          |        |         |         |         |         |      |      |
| PV ML                            |          |          |        |         |         |         |         |      |      |
| TOT OIL G                        |          |          |        |         |         |         |         |      |      |
| CUM H2O                          |          |          |        |         |         |         |         |      |      |
| CUM WOR                          |          |          |        |         |         |         |         |      |      |
| OIL REC                          |          |          |        |         |         |         |         |      |      |
| 177                              |          |          |        |         |         |         |         |      |      |
| SAMPLE #                         | PV INJ G | OIL PD G | H2O PD | CUM OIL | CUM H2O | CUM WOR | OIL REC |      |      |
| 1                                | 0.53     | 72.5     | 127.98 | 72.5    | 127.98  | 1.77    | 19.86   | 0.00 | 0.00 |
| 2                                | 0.98     | 18.53    | 156.15 | 91.03   | 284.13  | 3.12    | 24.93   |      |      |
| 3                                | 1.56     | 14.35    | 202.85 | 105.38  | 486.98  | 4.62    | 28.86   |      |      |
| 4                                | 2.17     | 8.01     | 225.25 | 113.39  | 712.23  | 6.28    | 31.06   |      |      |
| 5                                | 2.71     | 10.36    | 214.31 | 123.75  | 926.54  | 7.49    | 33.89   |      |      |
| 6                                | 3.33     | 8.58     | 214.02 | 132.33  | 1140.56 | 8.62    | 36.24   |      |      |
| 7                                | 3.85     | 7.23     | 188.59 | 139.56  | 1329.15 | 9.52    | 38.23   |      |      |
| 8                                | 4.04     | 3.58     | 65.92  | 143.14  | 1395.07 | 9.75    | 39.21   |      |      |
| 9                                |          | 15.68    | 73.81  | 158.82  | 1468.88 | 9.25    | 43.50   |      |      |
| 10                               |          | 41.36    | 30.59  | 200.18  | 1499.47 | 7.49    | 54.83   |      |      |
| 11                               |          | 13.18    | 0.43   | 213.36  | 1499.9  | 7.03    | 58.44   |      |      |

TABLE A-19

| TEST NO. 4-12 ( HOT WATER + N2 ) |          |          |        |         |         |         |         |      |      |
|----------------------------------|----------|----------|--------|---------|---------|---------|---------|------|------|
| INJ TEMP MAX 157 C               |          |          |        |         |         |         |         |      |      |
| PELICAN LAKE CRUDE               |          |          |        |         |         |         |         |      |      |
| 5 G/L BRINE                      |          |          |        |         |         |         |         |      |      |
| 55 MESH SAND                     |          |          |        |         |         |         |         |      |      |
| NOM H2O INJ ML/HR                |          |          |        |         |         |         |         |      |      |
| OUTLET PRESS PSIG                |          |          |        |         |         |         |         |      |      |
| PV ML                            |          |          |        |         |         |         |         |      |      |
| TOT OIL G                        |          |          |        |         |         |         |         |      |      |
| CUM H2O                          |          |          |        |         |         |         |         |      |      |
| CUM WOR                          |          |          |        |         |         |         |         |      |      |
| OIL REC                          |          |          |        |         |         |         |         |      |      |
| 177                              |          |          |        |         |         |         |         |      |      |
| SAMPLE #                         | PV INJ G | OIL PD G | H2O PD | CUM OIL | CUM H2O | CUM WOR | OIL REC |      |      |
| 1                                | 0.50     | 65.9     | 114.3  | 65.9    | 114.3   | 1.73    | 17.93   | 0.00 | 0.00 |
| 2                                | 0.99     | 18.32    | 183.74 | 84.22   | 298.04  | 3.54    | 22.92   |      |      |
| 3                                | 1.54     | 17.87    | 210.73 | 102.09  | 508.77  | 4.98    | 27.78   |      |      |
| 4                                | 2.14     | 19.32    | 224.89 | 121.41  | 733.66  | 6.04    | 33.04   |      |      |
| 5                                | 2.76     | 28.86    | 223.76 | 150.27  | 957.42  | 6.37    | 40.89   |      |      |
| 6                                | 3.38     | 17.82    | 237.48 |         | 1194.9  | 7.11    | 45.74   |      |      |
| 7                                | 4.02     | 16.67    | 234.75 |         | 1429.65 | 7.74    | 50.27   |      |      |
| 8                                |          | 8.04     | 82.94  | 192.8   | 1512.59 | 7.85    | 52.46   |      |      |
| 9                                |          | 35.66    | 44.52  | 228.46  | 1557.11 | 6.82    | 62.17   |      |      |
| 10                               |          | 12.13    | 7.56   | 240.59  | 1564.67 | 6.50    | 65.47   |      |      |
| 11                               |          | 15.52    | 0.5    | 256.11  | 1565.17 | 6.11    | 69.69   |      |      |

TABLE A-20

| TEST NO. 4-13 | INJ TEMP MAX 154 C | PELICAN LAKE CRUDE | 5 G/L BRINE | 55 MESH SAND | [ HOT WATER + N2 ] |                   |         |           |       | N2 L/HR | 36 |
|---------------|--------------------|--------------------|-------------|--------------|--------------------|-------------------|---------|-----------|-------|---------|----|
|               |                    |                    |             |              | NOM H2O INJ        | OUTLET PRESS PSIG | PV ML   | TOT OIL G | ML/HR |         |    |
|               |                    |                    |             |              | 530.0              | 100               | 421.5   | 371.7     |       |         |    |
| SAMPLE #      | PV INJ             | G OIL              | PD G        | H2O PD       | CUM OIL            | CUM H2O           | CUM WOR | OIL REC   |       |         |    |
| 1             | 0.41               | 66.07              | 92.29       | 0            | 66.07              | 92.29             | 0       | 0.00      | 0.00  | 17.78   |    |
| 2             | 0.71               | 14.56              | 107.7       | 80.63        | 199.98             | 2.48              | 21.69   |           |       |         |    |
| 3             | 1.02               | 9.65               | 113.26      | 90.28        | 313.25             | 3.47              | 24.29   |           |       |         |    |
| 4             | 1.33               | 9.25               | 112.57      | 99.53        | 425.82             | 4.28              | 26.78   |           |       |         |    |
| 5             | 1.64               | 8.73               | 114.52      | 108.26       | 540.34             | 4.99              | 29.13   |           |       |         |    |
| 6             | 2.06               | 8.59               | 156.06      | 116.85       | 696.4              | 5.96              | 31.44   |           |       |         |    |
| 7             | 2.47               | 12.23              | 149.24      | 129.08       | 845.64             | 6.55              | 34.73   |           |       |         |    |
| 8             | 2.88               | 10.96              | 151.08      | 140.04       | 996.72             | 7.12              | 37.68   |           |       |         |    |
| 9             | 3.31               | 13.35              | 153.89      | 153.39       | 1150.61            | 7.50              | 41.27   |           |       |         |    |
| 10            | 3.74               | 12.19              | 157.65      | 165.58       | 1308.26            | 7.90              | 44.55   |           |       |         |    |
| 11            | 4.15               | 14.1               | 152.64      | 179.68       | 1460.9             | 8.13              | 48.34   |           |       |         |    |
| 12            |                    | 14.7               | 87.91       | 194.38       | 1548.81            | 7.97              | 52.29   |           |       |         |    |
| 13            |                    | 42.19              | 22.55       | 236.57       | 1571.36            | 6.64              | 53.65   |           |       |         |    |
| 14            |                    | 4.17               | 9.5         | 240.74       | 1580.86            | 6.57              | 64.77   |           |       |         |    |

TABLE A-21

| TEST NO. 4-14 | INJ TEMP MAX 154 C | PELICAN LAKE CRUDE | 5 G/L BRINE | 55 MESH SAND | [ HOT WATER + N2 ] |                   |         |           |       | N2 L/HR | 36 |
|---------------|--------------------|--------------------|-------------|--------------|--------------------|-------------------|---------|-----------|-------|---------|----|
|               |                    |                    |             |              | NOM H2O INJ        | OUTLET PRESS PSIG | PV ML   | TOT OIL G | ML/HR |         |    |
|               |                    |                    |             |              | 1530.0             | 100               | 418.7   | 364.8     |       |         |    |
| SAMPLE #      | PV INJ             | G OIL              | PD G        | H2O PD       | CUM OIL            | CUM H2O           | CUM WOR | OIL REC   |       |         |    |
| 1             | 0.63               | 72.35              | 172.22      | 0            | 72.35              | 172.22            | 0       | 0.00      | 0.00  | 19.83   |    |
| 2             | 1.17               | 22.32              | 198.6       | 94.67        | 370.82             | 3.92              | 25.95   |           |       |         |    |
| 3             | 1.60               | 14.64              | 163.2       | 109.31       | 534.02             | 4.89              | 29.96   |           |       |         |    |
| 4             | 1.91               | 11.34              | 113.11      | 120.65       | 647.13             | 5.36              | 33.07   |           |       |         |    |
| 5             | 2.24               | 11.43              | 115.34      | 132.08       | 762.47             | 5.77              | 36.21   |           |       |         |    |
| 6             | 2.54               | 9.12               | 117.6       | 141.2        | 880.07             | 6.23              | 38.71   |           |       |         |    |
| 7             | 2.85               | 9.15               | 117         | 150.35       | 997.07             | 6.63              | 41.21   |           |       |         |    |
| 8             | 3.17               | 8.85               | 118.94      | 159.2        | 1116.01            | 7.01              | 43.64   |           |       |         |    |
| 9             | 3.50               | 8.83               | 123.16      | 168.03       | 1239.17            | 7.37              | 46.06   |           |       |         |    |
| 10            |                    | 7.06               | 73.1        | 175.09       | 1312.27            | 7.49              | 48.00   |           |       |         |    |
| 11            |                    | 38.96              | 43.98       | 214.05       | 1356.25            | 6.34              | 58.68   |           |       |         |    |
| 12            |                    | 10.22              | 6.5         | 224.27       | 1362.75            | 6.08              | 61.48   |           |       |         |    |

TABLE A-22

| TEST NO. 4-15      | [ HOT WATER + N2 ] |       |        |        | [ HOT WATER + N2 ] |       |         |         |
|--------------------|--------------------|-------|--------|--------|--------------------|-------|---------|---------|
| INJ TEMP MAX 154 C | PV                 | INJ   | G OIL  | PD     | G H2O              | PD    | CUM OIL | CUM H2O |
| PELICAN LAKE CRUDE | 0                  | 0     | 0      | 0      | 0                  | 0     | 0       | 0       |
| 5 G/L BRINE        | 0.19               | 47.06 | 27.78  | 47.06  | 27.78              | 47.06 | 27.78   | 47.06   |
| 55 MESH SAND       | 0.50               | 25.24 | 97.74  | 72.3   | 125.52             | 1.74  | 19.57   | 1.74    |
|                    | 0.94               | 19.73 | 149.19 | 92.03  | 274.71             | 2.99  | 24.91   | 2.99    |
|                    | 1.27               | 11.39 | 113.45 | 103.42 | 388.16             | 3.75  | 28.00   | 3.75    |
|                    | 1.57               | 9.32  | 108.52 | 112.74 | 496.68             | 4.41  | 30.52   | 4.41    |
|                    | 1.90               | 8.35  | 116.12 | 121.07 | 612.8              | 5.06  | 32.77   | 5.06    |
|                    | 2.22               | 9.68  | 112    | 130.75 | 724.8              | 5.54  | 35.40   | 5.54    |
|                    | 2.64               | 13.34 | 149.1  | 144.09 | 873.9              | 6.06  | 39.01   | 6.06    |
|                    | 3.07               | 12.2  | 154.12 | 156.29 | 1028.02            | 6.58  | 42.31   | 6.58    |
|                    | 3.49               | 14.07 | 145.25 | 170.36 | 1173.27            | 6.89  | 45.12   | 6.89    |
|                    | 4.12               | 17.4  | 225.57 | 187.76 | 1398.84            | 7.45  | 50.83   | 7.45    |
|                    |                    | 5.1   | 74.51  | 192.86 | 1473.35            | 7.64  | 52.21   | 7.64    |
|                    |                    | 38.81 | 39.59  | 231.67 | 1512.94            | 6.53  | 62.72   | 6.53    |
|                    |                    | 22.96 | 7.73   | 254.63 | 1520.67            | 5.97  | 68.93   | 5.97    |

INJ TEMP MAX 154 C  
PELICAN LAKE CRUDE  
5 G/L BRINE  
55 MESH SAND

530  
100  
423.4  
369.4

177

N2 L/HR

TABLE A-23

| TEST NO. 4-16      | [ HOT WATER + N2 ] |       |        |        | [ HOT WATER + N2 ] |      |         |         |
|--------------------|--------------------|-------|--------|--------|--------------------|------|---------|---------|
| INJ TEMP MAX 150 C | PV                 | INJ   | G OIL  | PD     | G H2O              | PD   | CUM OIL | CUM H2O |
| PELICAN LAKE CRUDE | 0                  | 0     | 0      | 0      | 0                  | 0    | 0       | 0       |
| 5 G/L BRINE        | 0.08               | 0     | 0      | 0      | 0                  | 0    | 0       | 0       |
| 55 MESH SAND       | 0.18               | 37.7  | 13.73  | 37.7   | 13.73              | 37.7 | 13.73   | 37.7    |
|                    | 0.65               | 32.59 | 147.11 | 70.29  | 160.44             | 2.29 | 18.92   | 2.29    |
|                    | 1.15               | 19.7  | 186.96 | 89.99  | 347.8              | 3.86 | 24.22   | 3.86    |
|                    | 1.67               | 16.96 | 192.2  | 106.95 | 540                | 5.05 | 28.79   | 5.05    |
|                    | 2.18               | 16.63 | 192.62 | 122.58 | 732.62             | 5.93 | 33.27   | 5.93    |
|                    | 2.70               | 15.97 |        | 926.69 |                    | 6.64 | 37.56   | 6.64    |
|                    | 3.22               | 11.06 | 198.98 | 150.61 | 1125.67            | 7.47 | 40.54   | 7.47    |
|                    | 3.55               | 10.66 | 121.92 | 161.27 | 1247.59            | 7.74 | 43.41   | 7.74    |
|                    | 3.89               | 9.2   | 123.57 | 170.47 | 1371.16            | 8.04 | 45.89   | 8.04    |
|                    | 4.23               | 10.38 | 124.9  | 180.85 | 1496.06            | 8.27 | 48.68   | 8.27    |
|                    |                    | 5.8   | 91.47  | 186.65 | 1587.53            | 8.51 | 50.24   | 8.51    |
|                    |                    | 43.97 | 21.64  | 230.62 | 1609.17            | 6.98 | 62.08   | 6.98    |
|                    |                    | 5.89  | 19.99  | 236.51 | 1629.16            | 6.89 | 63.66   | 6.89    |
|                    |                    | 15.75 | 1.58   | 252.26 | 1630.74            | 6.46 | 67.90   | 6.46    |

INJ TEMP MAX 150 C  
PELICAN LAKE CRUDE  
5 G/L BRINE  
55 MESH SAND

1530.0  
100-200  
423  
371.5

N2 L/HR

TABLE A-24

| TEST NO. 5-01 ( HOT WATER + M2 ) |      |       |        |        |         |       |       |       |       | TEST NO. 5-02 ( HOT WATER + CO2 ) |       |       |       |       |       |       |  |  |  |
|----------------------------------|------|-------|--------|--------|---------|-------|-------|-------|-------|-----------------------------------|-------|-------|-------|-------|-------|-------|--|--|--|
| INJ TEMP MAX 106 C               |      |       |        |        |         |       |       |       |       | INJ TEMP MAX 103 C                |       |       |       |       |       |       |  |  |  |
| PELICAN LAKE CRUDE               |      |       |        |        |         |       |       |       |       | PELICAN LAKE CRUDE                |       |       |       |       |       |       |  |  |  |
| 5 G/L BRINE                      |      |       |        |        |         |       |       |       |       | 5 G/L BRINE                       |       |       |       |       |       |       |  |  |  |
| 55 MESH SAND                     |      |       |        |        |         |       |       |       |       | 55 MESH SAND                      |       |       |       |       |       |       |  |  |  |
| PV ML                            |      |       |        |        |         |       |       |       |       | PV ML                             |       |       |       |       |       |       |  |  |  |
| TOT OIL G                        |      |       |        |        |         |       |       |       |       | TOT OIL G                         |       |       |       |       |       |       |  |  |  |
| 530.0 NOM N2 L/HR                |      |       |        |        |         |       |       |       |       | 530.0 CO2 L/HR                    |       |       |       |       |       |       |  |  |  |
| 100                              |      |       |        |        |         |       |       |       |       | 428.3                             |       |       |       |       |       |       |  |  |  |
| 381.3                            |      |       |        |        |         |       |       |       |       | 366.7                             |       |       |       |       |       |       |  |  |  |
| 358.1                            |      |       |        |        |         |       |       |       |       |                                   |       |       |       |       |       |       |  |  |  |
| SAMPLE #                         | PV   | INJ   | G      | OIL    | PD      | G     | H2O   | PD    | CUM   | OIL                               | CUM   | H2O   | CUM   | WOR   | OIL   | REC   |  |  |  |
|                                  | 0    | 0     | 0      | 0      | 0       | 0     | 0     | 0     | 0     | 0                                 | 0     | 0     | 0     | 0     | 0     | 0     |  |  |  |
| 1                                | 0.33 | 57.75 | 47.73  | 57.75  | 47.73   | 57.75 | 47.73 | 57.75 | 47.73 | 57.75                             | 47.73 | 57.75 | 47.73 | 57.75 | 47.73 | 57.75 |  |  |  |
| 2                                | 0.68 | 20.13 | 102.96 | 77.88  | 150.69  | 1.93  | 21.75 | 2.86  | 25.18 | 3.58                              | 27.69 | 4.25  | 30.54 | 4.92  | 32.92 | 35.34 |  |  |  |
| 3                                | 1.01 | 12.29 | 107.26 | 90.17  | 257.95  | 2.86  | 25.18 | 3.58  | 27.69 | 4.25                              | 30.54 | 4.92  | 32.92 | 35.34 | 37.39 | 41.70 |  |  |  |
| 4                                | 1.32 | 8.99  | 97.15  | 99.16  | 355.1   | 3.58  | 27.69 | 4.25  | 30.54 | 4.92                              | 32.92 | 35.34 | 37.39 | 41.70 | 43.70 | 45.96 |  |  |  |
| 5                                | 1.65 | 10.22 | 109.79 | 109.38 | 464.89  | 4.25  | 30.54 | 4.92  | 32.92 | 35.34                             | 37.39 | 41.70 | 43.70 | 45.96 | 47.90 | 49.90 |  |  |  |
| 6                                | 2.00 | 8.51  | 115.2  | 117.89 | 580.09  | 4.92  | 32.92 | 5.51  | 35.34 | 5.98                              | 37.39 | 6.39  | 43.70 | 6.95  | 45.96 | 47.90 |  |  |  |
| 7                                | 2.35 | 8.68  | 117.47 | 126.57 | 697.56  | 5.51  | 35.34 | 5.98  | 37.39 | 6.39                              | 43.70 | 6.95  | 45.96 | 47.90 | 49.90 | 51.30 |  |  |  |
| 8                                | 2.66 | 7.31  | 102.38 | 133.88 | 799.94  | 5.98  | 37.39 | 6.39  | 43.70 | 6.95                              | 45.96 | 47.90 | 49.90 | 51.30 | 53.74 | 54.91 |  |  |  |
| 9                                | 2.93 | 15.44 | 75.68  | 149.32 | 875.62  | 5.86  | 41.70 | 6.39  | 43.70 | 6.95                              | 45.96 | 47.90 | 49.90 | 51.30 | 53.74 | 54.91 |  |  |  |
| 10                               | 3.30 | 7.18  | 124.68 | 156.5  | 1000.3  | 6.39  | 43.70 | 6.95  | 45.96 | 47.90                             | 49.90 | 51.30 | 53.74 | 54.91 | 56.85 | 58.85 |  |  |  |
| 11                               | 3.71 | 8.07  | 143.72 | 164.57 | 1144.02 | 6.95  | 45.96 | 7.50  | 43.70 | 8.01                              | 46.56 | 8.24  | 47.90 | 8.49  | 61.01 | 63.31 |  |  |  |
| 12                               | 4.07 | 19.15 | 102.22 | 183.72 | 1246.24 | 6.78  | 51.30 | 7.09  | 53.74 | 7.34                              | 54.91 | 7.50  | 43.70 | 8.01  | 46.56 | 47.90 |  |  |  |
| 13                               | 4.42 | 8.74  | 118.89 | 192.46 | 1365.13 | 7.09  | 53.74 | 7.34  | 54.91 | 7.50                              | 43.70 | 8.01  | 46.56 | 8.24  | 47.90 | 49.90 |  |  |  |
| 14                               |      | 4.16  | 78.86  | 196.62 | 1443.99 | 7.34  | 54.91 | 7.50  | 43.70 | 8.01                              | 46.56 | 8.24  | 47.90 | 8.49  | 61.01 | 63.31 |  |  |  |
| 15                               |      | 23.93 | 41.71  | 220.55 | 1485.7  | 6.74  | 61.59 | 6.62  | 62.82 |                                   |       |       |       |       |       |       |  |  |  |
| 16                               |      | 4.42  | 3.56   | 224.97 | 1489.26 | 6.62  | 62.82 |       |       |                                   |       |       |       |       |       |       |  |  |  |

TABLE A-25

| TEST NO. 5-02 ( HOT WATER + CO2 ) |      |       |        |        |         |      |       |      |       | TEST NO. 5-01 ( HOT WATER + M2 ) |       |      |       |      |       |       |  |  |  |
|-----------------------------------|------|-------|--------|--------|---------|------|-------|------|-------|----------------------------------|-------|------|-------|------|-------|-------|--|--|--|
| INJ TEMP MAX 103 C                |      |       |        |        |         |      |       |      |       | INJ TEMP MAX 106 C               |       |      |       |      |       |       |  |  |  |
| PELICAN LAKE CRUDE                |      |       |        |        |         |      |       |      |       | PELICAN LAKE CRUDE               |       |      |       |      |       |       |  |  |  |
| 5 G/L BRINE                       |      |       |        |        |         |      |       |      |       | 5 G/L BRINE                      |       |      |       |      |       |       |  |  |  |
| 55 MESH SAND                      |      |       |        |        |         |      |       |      |       | 55 MESH SAND                     |       |      |       |      |       |       |  |  |  |
| PV ML                             |      |       |        |        |         |      |       |      |       | PV ML                            |       |      |       |      |       |       |  |  |  |
| TOT OIL G                         |      |       |        |        |         |      |       |      |       | TOT OIL G                        |       |      |       |      |       |       |  |  |  |
| 530.0 CO2 L/HR                    |      |       |        |        |         |      |       |      |       | 530.0 NOM N2 L/HR                |       |      |       |      |       |       |  |  |  |
| 428.3                             |      |       |        |        |         |      |       |      |       | 100                              |       |      |       |      |       |       |  |  |  |
| 366.7                             |      |       |        |        |         |      |       |      |       | 381.3                            |       |      |       |      |       |       |  |  |  |
|                                   |      |       |        |        |         |      |       |      |       | 358.1                            |       |      |       |      |       |       |  |  |  |
| SAMPLE #                          | PV   | INJ   | G      | OIL    | PD      | G    | H2O   | PD   | CUM   | OIL                              | CUM   | H2O  | CUM   | WOR  | OIL   | REC   |  |  |  |
|                                   | 0    | 0     | 0      | 0      | 0       | 0    | 0     | 0    | 0     | 0                                | 0     | 0    | 0     | 0    | 0     | 0     |  |  |  |
| 1                                 | 0.30 | 53.7  | 45.03  | 53.7   | 45.03   | 53.7 | 45.03 | 53.7 | 45.03 | 53.7                             | 45.03 | 53.7 | 45.03 | 53.7 | 45.03 | 53.7  |  |  |  |
| 2                                 | 0.62 | 19.66 | 100.2  | 73.36  | 145.23  | 1.98 | 20.01 | 2.89 | 24.03 | 3.71                             | 27.06 | 4.48 | 30.11 | 5.07 | 32.87 | 35.50 |  |  |  |
| 3                                 | 0.95 | 14.77 | 109.57 | 88.13  | 254.8   | 2.89 | 24.03 | 3.71 | 27.06 | 4.48                             | 30.11 | 5.07 | 32.87 | 5.63 | 35.50 | 38.14 |  |  |  |
| 4                                 | 1.28 | 11.11 | 113.6  | 99.24  | 368.4   | 3.71 | 27.06 | 4.48 | 30.11 | 5.07                             | 32.87 | 5.63 | 35.50 | 6.17 | 38.14 | 40.85 |  |  |  |
| 5                                 | 1.64 | 11.18 | 126.67 | 110.42 | 495.07  | 4.48 | 30.11 | 5.07 | 32.87 | 5.63                             | 35.50 | 6.17 | 38.14 | 6.89 | 40.85 | 43.70 |  |  |  |
| 6                                 | 1.97 | 10.13 | 116.58 | 120.55 | 611.65  | 5.07 | 32.87 | 5.63 | 35.50 | 6.17                             | 38.14 | 6.89 | 40.85 | 7.50 | 43.70 | 46.56 |  |  |  |
| 7                                 | 2.32 | 9.64  | 121.87 | 130.19 | 733.52  | 5.63 | 35.50 | 6.17 | 38.14 | 6.89                             | 40.85 | 7.50 | 43.70 | 8.01 | 46.56 | 47.90 |  |  |  |
| 8                                 | 2.67 | 9.66  | 129.31 | 139.85 | 862.83  | 6.17 | 38.14 | 6.89 | 40.85 | 7.50                             | 43.70 | 8.01 | 46.56 | 8.24 | 47.90 | 49.90 |  |  |  |
| 9                                 | 3.13 | 9.96  | 169.44 | 149.81 | 1032.27 | 6.89 | 40.85 | 7.50 | 43.70 | 8.01                             | 46.56 | 8.24 | 47.90 | 8.49 | 61.01 | 63.31 |  |  |  |
| 10                                | 3.60 | 10.44 | 169.19 | 160.25 | 1201.46 | 7.50 | 43.70 | 8.01 | 46.56 | 8.24                             | 47.90 | 8.49 | 61.01 | 8.62 | 63.31 | 65.62 |  |  |  |
| 11                                | 4.06 | 10.47 | 166.18 | 170.72 | 1367.64 | 8.01 | 46.56 | 8.24 | 47.90 | 8.49                             | 61.01 | 8.62 | 63.31 | 8.75 | 65.62 | 67.87 |  |  |  |
| 12                                |      | 4.93  | 79.43  | 175.65 | 1447.07 | 8.24 | 47.90 | 8.49 | 61.01 | 8.62                             | 63.31 | 8.75 | 65.62 | 8.88 | 67.87 | 69.99 |  |  |  |
| 13                                |      | 48.08 | 5.28   | 223.73 | 1452.35 | 6.49 | 61.01 | 6.78 | 62.82 |                                  |       |      |       |      |       |       |  |  |  |
| 14                                |      | 8.44  | 6.5    | 232.17 | 1458.85 | 6.28 | 63.31 |      |       |                                  |       |      |       |      |       |       |  |  |  |

TABLE A-26

| TEST NO. 5-03 [ HOT WATER + CO2 ] |  |  |  |  |  |  |  |  |  |
|-----------------------------------|--|--|--|--|--|--|--|--|--|
| INJ TEMP MAX 102 C                |  |  |  |  |  |  |  |  |  |
| PELICAN LAKE CRUDE                |  |  |  |  |  |  |  |  |  |
| 5 G/L BRINE                       |  |  |  |  |  |  |  |  |  |
| 125 MESH SAND                     |  |  |  |  |  |  |  |  |  |
| PV INJ G                          |  |  |  |  |  |  |  |  |  |
| TOT OIL G                         |  |  |  |  |  |  |  |  |  |
| 373.7                             |  |  |  |  |  |  |  |  |  |
| 530.0 CO2 L/HR                    |  |  |  |  |  |  |  |  |  |
| 36                                |  |  |  |  |  |  |  |  |  |

| SAMPLE # | PV INJ | G OIL | PD G   | H2O PD | CUM OIL | CUM H2O | CUM WOR | OIL REC | SAMPLE # | PV INJ | G OIL | PD G   | H2O PD | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|--------|-------|--------|--------|---------|---------|---------|---------|----------|--------|-------|--------|--------|---------|---------|---------|---------|
| 1        | 0.47   | 66.44 | 78.9   |        | 66.44   | 78.9    | 1.19    | 17.78   | 1        | 0.17   | 43.22 | 7.47   |        | 43.22   | 7.47    | 0.17    | 11.76   |
| 2        | 0.77   | 14.43 | 105.61 |        | 80.87   | 184.51  | 2.28    | 21.64   | 2        | 0.63   | 45.85 | 134.32 |        | 89.07   | 141.79  | 1.59    | 24.24   |
| 3        | 1.10   | 9.69  | 118.25 |        | 90.56   | 302.76  | 3.34    | 24.23   | 3        | 0.94   | 13.65 | 107.62 |        | 102.72  | 249.41  | 2.43    | 27.96   |
| 4        | 1.43   | 8.14  | 119.44 |        | 98.7    | 422.2   | 4.28    | 26.41   | 4        | 1.26   | 12.63 | 117.84 |        | 115.35  | 367.25  | 3.18    | 31.40   |
| 5        | 1.78   | 7.04  | 128.24 |        | 105.74  | 550.44  | 5.21    | 28.30   | 5        | 1.58   | 10.99 | 113.76 |        | 126.34  | 481.01  | 3.81    | 34.39   |
| 6        | 2.13   | 6.96  | 129.79 |        | 112.7   | 680.23  | 6.04    | 30.16   | 6        | 1.89   | 9.96  | 112.21 |        | 136.3   | 593.22  | 4.35    | 37.10   |
| 7        | 2.49   | 6.6   | 129.54 |        | 119.3   | 809.77  | 6.79    | 31.92   | 7        | 2.30   | 13.47 | 150.98 |        | 149.77  | 744.2   | 4.97    | 40.77   |
| 8        | 2.81   | 5.27  | 119.69 |        | 124.57  | 929.46  | 7.46    | 33.33   | 8        | 2.74   | 13.42 | 162.79 |        | 163.19  | 906.99  | 5.56    | 44.42   |
| 9        | 3.18   | 7.61  | 125.63 |        | 132.18  | 1055.09 | 7.98    | 35.37   | 9        | 3.18   | 12.49 | 163.05 |        | 175.68  | 1070.04 | 6.09    | 47.82   |
| 10       | 3.63   | 11.94 | 165.01 |        | 144.12  | 1220.1  | 8.47    | 38.57   | 10       | 3.61   | 11.99 | 163.93 |        | 187.67  | 1233.97 | 6.58    | 51.08   |
| 11       | 4.03   | 8.49  | 145.05 |        | 152.61  | 1365.15 | 8.95    | 40.84   | 11       | 4.04   | 11.13 | 163.27 |        | 198.8   | 1397.24 | 7.03    | 54.11   |
| 12       |        | 5.29  | 82.94  |        | 157.9   | 1448.09 | 9.17    | 42.25   | 12       |        | 4.82  | 83.87  |        | 203.62  | 1481.11 | 7.27    | 55.42   |
| 13       |        | 45.23 | 2.04   |        | 203.13  | 1450.13 | 7.14    | 54.36   | 13       |        | 40.08 | 11.2   |        | 243.7   | 1492.31 | 6.12    | 66.33   |
| 14       |        | 7.92  | 5.51   |        | 211.05  | 1455.64 | 6.90    | 56.48   | 14       |        | 10.5  | 6.6    |        | 254.2   | 1498.91 | 5.90    | 69.19   |

TABLE A-27

| TEST NO. 5-04 [ HOT WATER + CO2 ] |  |  |  |  |  |  |  |  |  |
|-----------------------------------|--|--|--|--|--|--|--|--|--|
| INJ TEMP MAX 102 C                |  |  |  |  |  |  |  |  |  |
| PELICAN LAKE CRUDE                |  |  |  |  |  |  |  |  |  |
| 5 G/L BRINE                       |  |  |  |  |  |  |  |  |  |
| 125 MESH SAND                     |  |  |  |  |  |  |  |  |  |
| PV INJ G                          |  |  |  |  |  |  |  |  |  |
| TOT OIL G                         |  |  |  |  |  |  |  |  |  |
| 367.39                            |  |  |  |  |  |  |  |  |  |
| 530.0 M2 L/HR                     |  |  |  |  |  |  |  |  |  |
| 36                                |  |  |  |  |  |  |  |  |  |

| SAMPLE # | PV INJ G | OIL PD G | H2O PD G | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|----------|----------|----------|---------|---------|---------|---------|
| 1        | 0.17     | 43.22    | 7.47     | 43.22   | 7.47    | 0.17    | 11.76   |
| 2        | 0.63     | 45.85    | 134.32   | 89.07   | 141.79  | 1.59    | 24.24   |
| 3        | 0.94     | 13.65    | 107.62   | 102.72  | 249.41  | 2.43    | 27.96   |
| 4        | 1.26     | 12.63    | 117.84   | 115.35  | 367.25  | 3.18    | 31.40   |
| 5        | 1.58     | 10.99    | 113.76   | 126.34  | 481.01  | 3.81    | 34.39   |
| 6        | 1.89     | 9.96     | 112.21   | 136.3   | 593.22  | 4.35    | 37.10   |
| 7        | 2.30     | 13.47    | 150.98   | 149.77  | 744.2   | 4.97    | 40.77   |
| 8        | 2.74     | 13.42    | 162.79   | 163.19  | 906.99  | 5.56    | 44.42   |
| 9        | 3.18     | 12.49    | 163.05   | 175.68  | 1070.04 | 6.09    | 47.82   |
| 10       | 3.61     | 11.99    | 163.93   | 187.67  | 1233.97 | 6.58    | 51.08   |
| 11       | 4.04     | 11.13    | 163.27   | 198.8   | 1397.24 | 7.03    | 54.11   |
| 12       |          | 4.82     | 83.87    | 203.62  | 1481.11 | 7.27    | 55.42   |
| 13       |          | 40.08    | 11.2     | 243.7   | 1492.31 | 6.12    | 66.33   |
| 14       |          | 10.5     | 6.6      | 254.2   | 1498.91 | 5.90    | 69.19   |

TABLE A-28

TEST NO. 5-05 ( HOT WATER + N2 )  
 INJ TEMP MAX 102 C  
 BUFFALO COULEE CRUDE  
 5 G/L BRINE  
 55 MESH SAND

NOM H2O INJ 530.0 N2 L/HR  
 OUTLET PRESS PSIG 375 / 90  
 PV ML 423.6  
 TOT OIL G 369.4

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| SAMPLE # | PV INJ G | OIL PD G | H2O PD G | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|----------|----------|----------|---------|---------|---------|---------|
| 1        | 0.37     | 69.41    | 72.1     | 69.41   | 72.1    | 0.00    | 0.00    |
| 2        | 0.70     | 15.43    | 111.8    | 84.84   | 183.9   | 2.17    | 22.97   |
| 3        | 1.03     | 11.26    | 117.8    | 96.1    | 301.7   | 3.14    | 26.02   |
| 4        | 1.37     | 9.09     | 123.81   | 105.19  | 425.51  | 4.05    | 28.48   |
| 5        | 1.70     | 8.26     | 115.09   | 113.45  | 540.6   | 4.77    | 30.71   |
| 6        | 2.02     | 6.45     | 115.84   | 119.9   | 656.44  | 5.47    | 32.46   |
| 7        | 2.35     | 8.62     | 119.99   | 128.52  | 776.43  | 6.04    | 34.79   |
| 8        | 2.68     | 8.13     | 119.45   | 136.65  | 895.88  | 6.56    | 36.99   |
| 9        | 3.00     | 7.68     | 119.15   | 144.33  | 1015.03 | 7.03    | 39.07   |
| 10       | 3.49     | 9.97     | 178.69   | 154.3   | 1193.72 | 7.74    | 41.77   |
| 11       | 4.08     | 12.27    | 221.78   | 166.57  | 1415.5  | 8.50    | 45.09   |
| 12       |          | 4.97     | 84.82    | 171.54  | 1500.32 | 8.75    | 46.44   |
| 13       |          | 48.36    | 8.35     | 219.9   | 1508.67 | 6.86    | 59.53   |
| 14       |          | 6.24     | 3        | 226.14  | 1511.67 | 6.68    | 61.22   |

TABLE A-29

TEST NO. 5-06 ( HOT WATER + N2 )  
 INJ TEMP MAX 102 C  
 BUFFALO COULEE CRUDE  
 5 G/L BRINE  
 55 MESH SAND

NOM H2O INJ 530.0 CO2 L/HR  
 OUTLET PRESS PSIG 350 / 50  
 PV ML 424.7  
 TOT OIL G 364.5

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| SAMPLE # | PV INJ G | OIL PD G | H2O PD G | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|----------|----------|----------|---------|---------|---------|---------|
| 1        | 0.22     | 57.22    | 22.72    | 57.22   | 22.72   | 0.00    | 0.00    |
| 2        | 0.57     | 21.17    | 115.07   | 78.39   | 137.79  | 1.76    | 21.51   |
| 3        | 0.92     | 13.33    | 124.34   | 91.72   | 262.13  | 2.86    | 25.16   |
| 4        | 1.27     | 10.58    | 127.71   | 102.3   | 389.84  | 3.81    | 28.07   |
| 5        | 1.62     | 11.51    | 125.67   | 113.81  | 515.51  | 4.53    | 31.22   |
| 6        | 1.98     | 9.36     | 131.48   | 123.17  | 646.99  | 5.25    | 33.79   |
| 7        | 2.32     | 8.64     | 123.53   | 131.81  | 770.52  | 5.85    | 36.16   |
| 8        | 2.66     | 8.18     | 125.75   | 139.99  | 896.27  | 6.40    | 38.41   |
| 9        | 3.12     | 10.14    | 167.78   | 150.13  | 1064.05 | 7.09    | 41.19   |
| 10       | 3.59     | 10.58    | 171.85   | 160.71  | 1235.9  | 7.69    | 44.09   |
| 11       | 4.05     | 10.17    | 175.46   | 170.88  | 1411.36 | 8.26    | 46.88   |
| 12       |          | 4.68     | 90.06    | 175.56  | 1501.42 | 8.55    | 48.16   |
| 13       |          | 36.56    | 1.35     | 212.12  | 1502.77 | 7.08    | 58.19   |
| 14       |          | 7.17     | 4.1      | 219.29  | 1506.87 | 6.87    | 60.16   |

TABLE A-30

| TEST NO. 5-07 [ HOT WATER + CO2 ]                        |      |       |        |        |         |       |       |    |     |     |     |     |      |       |     |      |
|----------------------------------------------------------|------|-------|--------|--------|---------|-------|-------|----|-----|-----|-----|-----|------|-------|-----|------|
| INJ TEMP MAX 102 C                                       |      |       |        |        |         |       |       |    |     |     |     |     |      |       |     |      |
| BUFFALO COULEE CRUDE                                     |      |       |        |        |         |       |       |    |     |     |     |     |      |       |     |      |
| 5 G/L BRINE                                              |      |       |        |        |         |       |       |    |     |     |     |     |      |       |     |      |
| 125 MESH SAND                                            |      |       |        |        |         |       |       |    |     |     |     |     |      |       |     |      |
| PV INJ G OIL PD G H2O PD CUM OIL CUM H2O CUM WOR OIL REC |      |       |        |        |         |       |       |    |     |     |     |     |      |       |     |      |
| SAMPLE #                                                 | PV   | INJ   | G      | OIL    | PD      | G     | H2O   | PD | CUM | OIL | CUM | H2O | CUM  | WOR   | OIL | REC  |
|                                                          | 0    |       |        |        | 0       |       |       | 0  |     |     |     | 0   |      | 0.00  |     | 0.00 |
| 1                                                        | 0.23 | 50.84 | 15.77  | 50.84  | 15.77   | 50.84 | 15.77 |    |     |     |     |     | 0.31 | 13.87 |     |      |
| 2                                                        | 0.63 | 26.56 | 130.32 | 77.4   | 146.09  | 1.89  | 21.11 |    |     |     |     |     | 3.92 | 28.20 |     |      |
| 3                                                        | 1.03 | 15.27 | 145.43 | 92.67  | 291.52  | 3.15  | 25.28 |    |     |     |     |     | 4.48 | 31.54 |     |      |
| 4                                                        | 1.34 | 10.72 | 114.18 | 103.39 | 405.7   | 5.16  | 34.72 |    |     |     |     |     | 5.89 | 38.56 |     |      |
| 5                                                        | 1.65 | 12.23 | 112.64 | 115.62 | 518.34  | 6.45  | 43.09 |    |     |     |     |     | 5.98 | 47.05 |     |      |
| 6                                                        | 2.02 | 11.65 | 138.38 | 127.27 | 656.72  | 7.51  | 50.59 |    |     |     |     |     | 7.73 | 51.83 |     |      |
| 7                                                        | 2.50 | 14.1  | 175.69 | 141.37 | 832.41  | 6.37  | 63.26 |    |     |     |     |     | 6.12 | 66.08 |     |      |
| 8                                                        | 3.00 | 16.61 | 186.48 | 157.98 | 1018.89 |       |       |    |     |     |     |     |      |       |     |      |
| 9                                                        | 3.50 | 14.51 | 184.97 | 172.49 | 1203.86 |       |       |    |     |     |     |     |      |       |     |      |
| 10                                                       | 4.00 | 12.98 | 189.47 | 185.47 | 1393.33 |       |       |    |     |     |     |     |      |       |     |      |
| 11                                                       |      | 4.55  | 75.16  | 190.02 | 1468.49 |       |       |    |     |     |     |     |      |       |     |      |
| 12                                                       |      | 41.9  | 9.3    | 231.92 | 1477.79 |       |       |    |     |     |     |     |      |       |     |      |
| 13                                                       |      | 10.33 | 5.8    | 242.25 | 1483.59 |       |       |    |     |     |     |     |      |       |     |      |

TABLE A-31

| TEST NO. 5-08 [ HOT WATER + N2 ]                         |      |       |        |        |         |      |       |    |      |      |       |     |      |      |      |      |
|----------------------------------------------------------|------|-------|--------|--------|---------|------|-------|----|------|------|-------|-----|------|------|------|------|
| INJ TEMP MAX 102 C                                       |      |       |        |        |         |      |       |    |      |      |       |     |      |      |      |      |
| PELICAN LAKE CRUDE                                       |      |       |        |        |         |      |       |    |      |      |       |     |      |      |      |      |
| 5 G/L BRINE                                              |      |       |        |        |         |      |       |    |      |      |       |     |      |      |      |      |
| 125 MESH SAND                                            |      |       |        |        |         |      |       |    |      |      |       |     |      |      |      |      |
| PV INJ G OIL PD G H2O PD CUM OIL CUM H2O CUM WOR OIL REC |      |       |        |        |         |      |       |    |      |      |       |     |      |      |      |      |
| SAMPLE #                                                 | PV   | INJ   | G      | OIL    | PD      | G    | H2O   | PD | CUM  | OIL  | CUM   | H2O | CUM  | WOR  | OIL  | REC  |
|                                                          | 0    |       |        |        | 0       |      |       | 0  |      |      |       |     |      |      |      |      |
| 1                                                        | 0.23 | 57.12 | 24.73  | 57.12  | 24.73   | 0.43 | 15.45 | 0  | 0.00 | 0.43 | 15.45 | 0   | 0.00 | 0.00 | 0.00 | 0.00 |
| 2                                                        | 0.53 | 20.54 | 99.94  | 77.66  | 124.67  | 1.61 | 21.00 | 0  | 0.00 | 1.61 | 21.00 | 0   | 0.00 | 0.00 | 0.00 | 0.00 |
| 3                                                        | 0.83 | 12.73 | 106.86 | 90.39  | 231.53  | 2.56 | 24.44 | 0  | 0.00 | 2.56 | 24.44 | 0   | 0.00 | 0.00 | 0.00 | 0.00 |
| 4                                                        | 1.22 | 11.98 | 145.71 | 102.37 | 377.24  | 3.69 | 27.68 | 0  | 0.00 | 3.69 | 27.68 | 0   | 0.00 | 0.00 | 0.00 | 0.00 |
| 5                                                        | 1.64 | 15.84 | 153.12 | 118.21 | 530.36  | 4.49 | 31.97 | 0  | 0.00 | 4.49 | 31.97 | 0   | 0.00 | 0.00 | 0.00 | 0.00 |
| 6                                                        | 2.05 | 12.6  | 152.32 | 130.81 | 682.68  | 5.22 | 35.37 | 0  | 0.00 | 5.22 | 35.37 | 0   | 0.00 | 0.00 | 0.00 | 0.00 |
| 7                                                        | 2.48 | 11.45 | 162.05 | 142.26 | 844.73  | 5.94 | 38.47 | 0  | 0.00 | 5.94 | 38.47 | 0   | 0.00 | 0.00 | 0.00 | 0.00 |
| 8                                                        | 2.89 | 11.43 | 154.82 | 153.69 | 999.55  | 6.50 | 41.56 | 0  | 0.00 | 6.50 | 41.56 | 0   | 0.00 | 0.00 | 0.00 | 0.00 |
| 9                                                        | 3.28 | 10.56 | 147.1  | 164.25 | 1146.65 | 6.98 | 44.42 | 0  | 0.00 | 6.98 | 44.42 | 0   | 0.00 | 0.00 | 0.00 | 0.00 |
| 10                                                       | 3.73 | 13.54 | 159.8  | 177.79 | 1306.45 | 7.35 | 48.08 | 0  | 0.00 | 7.35 | 48.08 | 0   | 0.00 | 0.00 | 0.00 | 0.00 |
| 11                                                       | 4.04 | 8.54  | 122.11 | 186.33 | 1428.56 | 7.67 | 50.39 | 0  | 0.00 | 7.67 | 50.39 | 0   | 0.00 | 0.00 | 0.00 | 0.00 |
| 12                                                       |      | 9.09  | 72.17  | 195.42 | 1500.73 | 7.68 | 52.84 | 0  | 0.00 | 7.68 | 52.84 | 0   | 0.00 | 0.00 | 0.00 | 0.00 |
| 13                                                       |      | 37.16 | 15.16  | 232.58 | 1515.89 | 6.52 | 62.89 | 0  | 0.00 | 6.52 | 62.89 | 0   | 0.00 | 0.00 | 0.00 | 0.00 |
| 14                                                       |      | 10.08 | 4.42   | 242.66 | 1520.31 | 6.27 | 65.62 | 0  | 0.00 | 6.27 | 65.62 | 0   | 0.00 | 0.00 | 0.00 | 0.00 |

TABLE A-32

TEST NO. 6-01  
INJ TEMP MAX 102 C  
PELICAN LAKE CRUDE  
1 G/L BRINE  
55 MESH SAND

[ HOT WATER + .5 PV OF 1 G/L NAOH + M2 ]  
NOM H2O INJ ML/HR 530.0 M2 L/HR  
OUTLET PRESS PSIG 410 / 100  
PV ML 421.1  
TOT OIL G 366.1

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| SAMPLE # | PV   | INJ   | G      | OIL    | PD | G | H2O     | PD | CUM    | OIL | CUM | H2O     | CUM | WOR  | OIL   | REC  |
|----------|------|-------|--------|--------|----|---|---------|----|--------|-----|-----|---------|-----|------|-------|------|
|          | 0    |       |        |        | 0  |   | 0       |    | 0      |     |     | 0       |     | 0.00 | 0.00  | 0.00 |
| 1        | 0.23 | 43.54 | 48.32  | 43.54  |    |   | 48.32   |    | 43.54  |     |     | 48.32   |     | 1.11 | 11.89 |      |
| 2        | 0.66 | 22.79 | 156.6  | 66.33  |    |   | 204.92  |    | 66.33  |     |     | 204.92  |     | 3.09 | 18.12 |      |
| 3        | 1.08 | 12.21 | 164.3  | 78.54  |    |   | 369.22  |    | 78.54  |     |     | 369.22  |     | 4.70 | 21.45 |      |
| 4        | 1.44 | 11.06 | 141.83 | 89.6   |    |   | 511.05  |    | 89.6   |     |     | 511.05  |     | 5.70 | 24.47 |      |
| 5        | 1.87 | 13.31 | 163.33 | 102.91 |    |   | 674.38  |    | 102.91 |     |     | 674.38  |     | 6.55 | 28.11 |      |
| 6        | 2.28 | 13.23 | 160.1  | 116.14 |    |   | 834.48  |    | 116.14 |     |     | 834.48  |     | 7.19 | 31.72 |      |
| 7        | 2.69 | 11.44 | 156    | 127.58 |    |   | 990.48  |    | 127.58 |     |     | 990.48  |     | 7.76 | 34.85 |      |
| 8        | 3.20 | 13.95 | 199.6  | 141.53 |    |   | 1190.08 |    | 141.53 |     |     | 1190.08 |     | 8.41 | 38.66 |      |
| 9        | 3.59 | 11.14 | 157.04 | 152.67 |    |   | 1347.12 |    | 152.67 |     |     | 1347.12 |     | 8.82 | 41.70 |      |
| 10       | 3.99 | 10.76 | 158.25 | 163.43 |    |   | 1505.37 |    | 163.43 |     |     | 1505.37 |     | 9.21 | 44.64 |      |
| 11       |      | 10.63 | 126.3  | 174.06 |    |   | 1631.67 |    | 174.06 |     |     | 1631.67 |     | 9.37 | 47.54 |      |
| 12       |      | 8.9   | 92.81  | 182.96 |    |   | 1724.48 |    | 182.96 |     |     | 1724.48 |     | 9.43 | 49.98 |      |
| 13       |      | 17.11 | 79.05  | 200.07 |    |   | 1803.53 |    | 200.07 |     |     | 1803.53 |     | 9.01 | 54.65 |      |
| 14       |      | 49.43 | 10     | 249.5  |    |   | 1813.53 |    | 249.5  |     |     | 1813.53 |     | 7.27 | 68.15 |      |
| 15       |      | 24.19 | 19.15  | 273.69 |    |   | 1832.68 |    | 273.69 |     |     | 1832.68 |     | 6.70 | 74.76 |      |
| 16       |      | 5.68  | 14.56  | 279.37 |    |   | 1847.24 |    | 279.37 |     |     | 1847.24 |     | 6.61 | 76.31 |      |

TABLE A-33

TEST NO. 6-02  
INJ TEMP MAX 102 C  
PELICAN LAKE CRUDE  
1 G/L BRINE  
55 MESH SAND

[ HOT WATER + .5 PV OF 5 G/L NAOH + M2 ]  
NOM H2O INJ ML/HR 530.0 M2 L/HR  
OUTLET PRESS PSIG 400 / 100  
PV ML 423.8  
TOT OIL G 372.6

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| SAMPLE # | PV   | INJ   | G      | OIL    | PD | G | H2O     | PD | CUM    | OIL | CUM | H2O     | CUM | WOR  | OIL   | REC  |
|----------|------|-------|--------|--------|----|---|---------|----|--------|-----|-----|---------|-----|------|-------|------|
|          | 0    |       |        |        | 0  |   | 0       |    | 0      |     |     | 0       |     | 0.00 | 0.00  | 0.00 |
| 1        | 0.28 | 57.92 | 56.29  | 57.92  |    |   | 56.29   |    | 57.92  |     |     | 56.29   |     | 0.97 | 15.54 |      |
| 2        | 0.61 | 17.12 | 119.3  | 75.04  |    |   | 175.59  |    | 75.04  |     |     | 175.59  |     | 2.34 | 20.14 |      |
| 3        | 0.92 | 12.54 | 116.4  | 87.58  |    |   | 291.99  |    | 87.58  |     |     | 291.99  |     | 3.33 | 23.51 |      |
| 4        | 1.23 | 11.06 | 120.85 | 98.64  |    |   | 412.84  |    | 98.64  |     |     | 412.84  |     | 4.19 | 26.47 |      |
| 5        | 1.56 | 11.58 | 123.02 | 110.22 |    |   | 535.86  |    | 110.22 |     |     | 535.86  |     | 4.86 | 29.58 |      |
| 6        | 1.95 | 12.13 | 154.46 | 122.35 |    |   | 690.32  |    | 122.35 |     |     | 690.32  |     | 5.64 | 32.84 |      |
| 7        | 2.38 | 12.01 | 163.42 | 134.36 |    |   | 853.74  |    | 134.36 |     |     | 853.74  |     | 6.35 | 36.06 |      |
| 8        | 2.80 | 11.97 | 161.72 | 146.33 |    |   | 1015.46 |    | 146.33 |     |     | 1015.46 |     | 6.94 | 39.27 |      |
| 9        | 3.21 | 11.66 | 160.2  | 157.99 |    |   | 1175.66 |    | 157.99 |     |     | 1175.66 |     | 7.44 | 42.40 |      |
| 10       | 3.63 | 11.6  | 158.05 | 169.59 |    |   | 1333.71 |    | 169.59 |     |     | 1333.71 |     | 7.86 | 45.52 |      |
| 11       |      | 11.78 | 156.6  | 181.37 |    |   | 1490.31 |    | 181.37 |     |     | 1490.31 |     | 8.22 | 48.68 |      |
| 12       |      | 7.8   | 84.78  | 189.17 |    |   | 1575.09 |    | 189.17 |     |     | 1575.09 |     | 8.33 | 50.77 |      |
| 13       |      | 8.65  | 136.74 | 197.82 |    |   | 1711.83 |    | 197.82 |     |     | 1711.83 |     | 8.65 | 53.09 |      |
| 14       |      | 36.51 | 60.12  | 234.33 |    |   | 1771.95 |    | 234.33 |     |     | 1771.95 |     | 7.56 | 62.89 |      |
| 15       |      | 41.26 | 25.45  | 275.59 |    |   | 1797.4  |    | 275.59 |     |     | 1797.4  |     | 6.52 | 73.96 |      |
| 16       |      | 3.83  | 24.44  | 279.42 |    |   | 1821.84 |    | 279.42 |     |     | 1821.84 |     | 6.52 | 74.99 |      |
| 17       |      | 1.57  | 6.55   | 280.99 |    |   | 1828.39 |    | 280.99 |     |     | 1828.39 |     | 6.51 | 75.41 |      |

TABLE A-34

TEST NO. 6-03 ( HOT WATER + .5 PV OF 5 G/L TRS + M2 )  
 INJ TEMP MAX 101 C NOM H2O INJ ML/HR 530.0 M2 L/HR 36  
 PELICAN LAKE CRUDE OUTLET PRESS PSIG 250 / 100  
 1 G/L BRINE PV ML 420.4  
 55 MESH SAND TOT OIL G 377.5

| SAMPLE # | PV   | INJ   | G | OIL    | PD | G      | H2O     | PD | CUM  | OIL | CUM   | H2O | CUM  | WOR   | OIL  | REC  |
|----------|------|-------|---|--------|----|--------|---------|----|------|-----|-------|-----|------|-------|------|------|
|          | 0    |       |   |        | 0  |        | 0       |    | 0    |     | 0     |     | 0    | 0.00  | 0.00 | 0.00 |
| 1        | 0.50 | 72.53 |   | 132.57 |    | 72.53  | 132.57  |    | 1.83 |     | 19.21 |     | 1.83 | 19.21 |      | 0.00 |
| 2        | 0.83 | 12.93 |   | 121.55 |    | 85.46  | 254.12  |    | 2.97 |     | 22.64 |     | 2.97 | 22.64 |      | 0.00 |
| 3        | 1.13 |       | 9 | 114.62 |    | 94.46  | 368.74  |    | 3.90 |     | 25.02 |     | 3.90 | 25.02 |      | 0.00 |
| 4        | 1.45 | 10.16 |   | 120.54 |    | 104.62 | 489.28  |    | 4.68 |     | 27.71 |     | 4.68 | 27.71 |      | 0.00 |
| 5        | 1.64 | 6.41  |   | 70.01  |    | 111.03 | 559.29  |    | 5.04 |     | 29.41 |     | 5.04 | 29.41 |      | 0.00 |
| 6        | 1.94 | 9.24  |   | 105.1  |    | 120.27 | 664.39  |    | 5.52 |     | 31.86 |     | 5.52 | 31.86 |      | 0.00 |
| 7        | 2.37 | 11.69 |   | 165.88 |    | 131.96 | 830.27  |    | 6.29 |     | 34.96 |     | 6.29 | 34.96 |      | 0.00 |
| 8        | 2.82 | 12.07 |   | 174.12 |    | 144.03 | 1004.39 |    | 6.97 |     | 38.15 |     | 6.97 | 38.15 |      | 0.00 |
| 9        | 3.24 | 11.55 |   | 163.7  |    | 155.58 | 1168.09 |    | 7.51 |     | 41.21 |     | 7.51 | 41.21 |      | 0.00 |
| 10       | 3.67 | 11.01 |   | 166.64 |    | 166.59 | 1334.73 |    | 8.01 |     | 44.13 |     | 8.01 | 44.13 |      | 0.00 |
| 11       | 4.01 | 10.67 |   | 131.53 |    | 177.26 | 1466.26 |    | 8.27 |     | 46.96 |     | 8.27 | 46.96 |      | 0.00 |
| 12       |      | 7.92  |   | 113.8  |    | 185.18 | 1580.06 |    | 8.53 |     | 49.05 |     | 8.53 | 49.05 |      | 0.00 |
| 13       |      | 6.11  |   | 108.48 |    | 191.29 | 1688.54 |    | 8.83 |     | 50.67 |     | 8.83 | 50.67 |      | 0.00 |
| 14       |      | 12.09 |   | 72.4   |    | 203.38 | 1760.94 |    | 8.66 |     | 53.88 |     | 8.66 | 53.88 |      | 0.00 |
| 15       |      | 46.4  |   | 12.67  |    | 249.78 | 1773.61 |    | 7.10 |     | 66.17 |     | 7.10 | 66.17 |      | 0.00 |
| 16       |      | 9.05  |   | 11.76  |    | 258.83 | 1785.37 |    | 6.90 |     | 68.56 |     | 6.90 | 68.56 |      | 0.00 |

TABLE A-35

TEST NO. 6-04 ( HOT WATER + .57 PV OF 3 G/L TRS + M2 )  
 INJ TEMP MAX 100 C NOM H2O INJ ML/HR 530.0 M2 L/HR 36  
 PELICAN LAKE CRUDE OUTLET PRESS PSIG 575 / 100  
 1 G/L BRINE PV ML 425  
 55 MESH SAND TOT OIL G 370.1

| SAMPLE # | PV   | INJ   | G | OIL    | PD | G      | H2O     | PD | CUM  | OIL | CUM   | H2O | CUM  | WOR   | OIL  | REC  |
|----------|------|-------|---|--------|----|--------|---------|----|------|-----|-------|-----|------|-------|------|------|
|          | 0    |       |   |        | 0  |        | 0       |    | 0    |     | 0     |     | 0    | 0.00  | 0.00 | 0.00 |
| 1        | 0.28 | 60.05 |   | 55.86  |    | 60.05  | 55.86   |    | 0.93 |     | 16.23 |     | 0.93 | 16.23 |      | 0.00 |
| 2        | 0.62 | 18.77 |   | 124.57 |    | 78.82  | 180.43  |    | 2.29 |     | 21.30 |     | 2.29 | 21.30 |      | 0.00 |
| 3        | 0.88 | 16.69 |   | 92.3   |    | 95.51  | 272.73  |    | 2.86 |     | 25.81 |     | 2.86 | 25.81 |      | 0.00 |
| 4        | 1.10 | 8.02  |   | 82.18  |    | 103.53 | 354.91  |    | 3.43 |     | 27.97 |     | 3.43 | 27.97 |      | 0.00 |
| 5        | 1.55 | 14.2  |   | 175.32 |    | 117.73 | 530.23  |    | 4.50 |     | 31.81 |     | 4.50 | 31.81 |      | 0.00 |
| 6        | 1.98 | 12.59 |   | 172.31 |    | 130.32 | 702.54  |    | 5.39 |     | 35.21 |     | 5.39 | 35.21 |      | 0.00 |
| 7        | 2.36 | 11.44 |   | 144.13 |    | 141.76 | 846.67  |    | 5.97 |     | 38.30 |     | 5.97 | 38.30 |      | 0.00 |
| 8        | 2.83 | 12.52 |   | 176.07 |    | 154.28 | 1022.74 |    | 6.63 |     | 41.69 |     | 6.63 | 41.69 |      | 0.00 |
| 9        | 3.24 | 13.11 |   | 159.01 |    | 167.39 | 1181.75 |    | 7.06 |     | 45.23 |     | 7.06 | 45.23 |      | 0.00 |
| 10       | 3.62 | 12.62 |   | 151.35 |    | 180.01 | 1333.1  |    | 7.41 |     | 48.64 |     | 7.41 | 48.64 |      | 0.00 |
| 11       | 4.02 |       | 9 | 154.62 |    | 189.01 | 1487.72 |    | 7.87 |     | 51.07 |     | 7.87 | 51.07 |      | 0.00 |
| 12       |      | 7.89  |   | 117.11 |    | 196.9  | 1604.83 |    | 8.15 |     | 53.20 |     | 8.15 | 53.20 |      | 0.00 |
| 13       |      | 6.65  |   | 109    |    | 203.55 | 1713.83 |    | 8.42 |     | 55.00 |     | 8.42 | 55.00 |      | 0.00 |
| 14       |      | 5     |   | 87.74  |    | 208.55 | 1801.57 |    | 8.64 |     | 56.35 |     | 8.64 | 56.35 |      | 0.00 |
| 15       |      | 22.6  |   | 36.26  |    | 231.15 | 1837.83 |    | 7.95 |     | 62.46 |     | 7.95 | 62.46 |      | 0.00 |
| 16       |      | 6.17  |   | 11.9   |    | 237.32 | 1849.73 |    | 7.79 |     | 64.12 |     | 7.79 | 64.12 |      | 0.00 |

TABLE A-36

TEST NO. 6-05  
 INJ TEMP MAX 102 C  
 BUFFALO COULEE CRUDE  
 1 G/L BRINE  
 55 MESH SAND

I HOT WATER + .57 PV OF 1 G/L MAOH + N2 J  
 NOM H2O INJ ML/HR 530.0 N2 L/HR  
 OUTLET PRESS PSIG 275 / 100  
 PV ML 428.7  
 TOT OIL G 375.6

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| SAMPLE # | PV   | INJ   | G      | OIL    | PD      | G     | H2O   | PD    | CUM   | OIL   | CUM   | H2O   | CUM   | WOR   | OIL    | REC    |
|----------|------|-------|--------|--------|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|
|          | 0    | 0     | 0      | 0      | 0       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0.00  | 0.00   | 0.00   |
| 1        | 0.19 | 55.94 | 24.19  | 55.94  | 24.19   | 55.94 | 24.19 | 55.94 | 24.19 | 55.94 | 24.19 | 55.94 | 24.19 | 0.43  | 14.89  | 14.89  |
| 2        | 0.43 | 18.24 | 77.55  | 74.18  | 101.74  | 1.37  | 19.75 | 2.59  | 23.36 | 3.97  | 26.87 | 5.11  | 30.36 | 6.04  | 33.02  | 35.77  |
| 3        | 0.77 | 13.55 | 125.74 | 87.73  | 227.48  | 2.59  | 23.36 | 3.97  | 26.87 | 5.11  | 30.36 | 6.04  | 33.02 | 6.84  | 35.77  | 38.22  |
| 4        | 1.20 | 13.19 | 172.91 | 100.92 | 400.39  | 5.11  | 30.36 | 6.04  | 33.02 | 6.84  | 35.77 | 7.59  | 38.22 | 8.33  | 40.74  | 43.97  |
| 5        | 1.66 | 13.13 | 182.2  | 114.05 | 582.59  | 5.11  | 30.36 | 6.04  | 33.02 | 6.84  | 35.77 | 7.59  | 38.22 | 9.18  | 43.97  | 45.69  |
| 6        | 2.08 | 9.96  | 166.71 | 124.01 | 749.3   | 5.11  | 30.36 | 6.04  | 33.02 | 6.84  | 35.77 | 7.59  | 38.22 | 9.56  | 45.69  | 47.31  |
| 7        | 2.51 | 10.34 | 169.46 | 134.35 | 918.76  | 5.11  | 30.36 | 6.04  | 33.02 | 6.84  | 35.77 | 7.59  | 38.22 | 9.86  | 47.31  | 53.30  |
| 8        | 2.94 | 9.46  | 185    | 143.55 | 1089.6  | 5.11  | 30.36 | 6.04  | 33.02 | 6.84  | 35.77 | 7.59  | 38.22 | 10.17 | 53.30  | 61.23  |
| 9        | 3.40 | 12.14 | 241.6  | 153.01 | 1274.6  | 5.11  | 30.36 | 6.04  | 33.02 | 6.84  | 35.77 | 7.59  | 38.22 | 10.47 | 61.23  | 69.16  |
| 10       | 4.00 | 6.45  | 124.01 | 171.6  | 1640.21 | 5.11  | 30.36 | 6.04  | 33.02 | 6.84  | 35.77 | 7.59  | 38.22 | 10.77 | 69.16  | 77.10  |
| 11       |      | 6.09  | 111.99 | 177.69 | 1752.2  | 5.11  | 30.36 | 6.04  | 33.02 | 6.84  | 35.77 | 7.59  | 38.22 | 11.07 | 77.10  | 85.03  |
| 12       |      | 22.5  | 55.8   | 200.19 | 1808    | 5.11  | 30.36 | 6.04  | 33.02 | 6.84  | 35.77 | 7.59  | 38.22 | 11.37 | 85.03  | 92.96  |
| 13       |      | 29.70 | 56.03  | 229.97 | 1864.03 | 5.11  | 30.36 | 6.04  | 33.02 | 6.84  | 35.77 | 7.59  | 38.22 | 11.67 | 92.96  | 100.89 |
| 14       |      | 2.72  | 11.02  | 232.69 | 1875.05 | 5.11  | 30.36 | 6.04  | 33.02 | 6.84  | 35.77 | 7.59  | 38.22 | 11.97 | 100.89 | 108.82 |
| 15       |      |       |        |        |         | 5.11  | 30.36 | 6.04  | 33.02 | 6.84  | 35.77 | 7.59  | 38.22 | 12.27 | 108.82 | 116.75 |

TABLE A-37

TEST NO. 6-06  
 INJ TEMP MAX 101 C  
 BUFFALO COULEE CRUDE  
 1 G/L BRINE  
 55 MESH SAND

I HOT WATER + .5 PV OF 5 G/L MAOH + N2 J  
 NOM H2O INJ ML/HR 530.0 N2 L/HR  
 OUTLET PRESS PSIG 410 / 100  
 PV ML 415.7  
 TOT OIL G 369.8

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| SAMPLE # | PV    | INJ    | G      | OIL     | PD      | G     | H2O   | PD    | CUM   | OIL   | CUM   | H2O   | CUM    | WOR   | OIL    | REC    |
|----------|-------|--------|--------|---------|---------|-------|-------|-------|-------|-------|-------|-------|--------|-------|--------|--------|
|          | 0     | 0      | 0      | 0       | 0       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0      | 0.00  | 0.00   | 0.00   |
| 1        | 0.28  | 57.56  | 44.1   | 57.56   | 44.1    | 57.56 | 44.1  | 57.56 | 44.1  | 57.56 | 44.1  | 57.56 | 44.1   | 0.77  | 15.57  | 15.57  |
| 2        | 0.60  | 21.46  | 109.57 | 79.02   | 153.67  | 1.94  | 21.37 | 2.95  | 24.89 | 3.80  | 27.49 | 4.20  | 30.05  | 5.10  | 33.50  | 36.56  |
| 3        | 0.92  | 13.01  | 118    | 92.03   | 271.67  | 2.95  | 24.89 | 3.80  | 27.49 | 4.20  | 30.05 | 5.10  | 33.50  | 6.02  | 36.56  | 38.97  |
| 4        | 1.22  | 9.61   | 114.06 | 101.64  | 385.73  | 3.80  | 27.49 | 4.20  | 30.05 | 5.10  | 33.50 | 6.02  | 36.56  | 6.77  | 38.97  | 41.46  |
| 5        | 1.47  | 9.48   | 81.39  | 111.12  | 467.12  | 4.20  | 30.05 | 5.10  | 33.50 | 6.02  | 36.56 | 6.77  | 38.97  | 7.50  | 41.46  | 44.18  |
| 6        | 1.92  | 12.78  | 164.34 | 123.9   | 631.46  | 5.10  | 33.50 | 6.02  | 36.56 | 6.77  | 38.97 | 7.50  | 41.46  | 8.09  | 44.18  | 45.85  |
| 7        | 2.39  | 11.29  | 182.23 | 135.19  | 813.69  | 6.02  | 36.56 | 6.77  | 38.97 | 7.50  | 41.46 | 8.09  | 44.18  | 8.46  | 45.85  | 47.73  |
| 8        | 2.82  | 8.93   | 162.46 | 144.12  | 976.15  | 6.77  | 38.97 | 7.50  | 41.46 | 8.09  | 44.18 | 8.46  | 45.85  | 8.78  | 47.73  | 49.43  |
| 9        | 3.28  | 9.2    | 174.27 | 153.32  | 1150.42 | 7.50  | 41.46 | 8.09  | 44.18 | 8.46  | 45.85 | 8.78  | 47.73  | 9.06  | 49.43  | 56.94  |
| 10       | 3.73  | 10.06  | 171.17 | 163.38  | 1321.59 | 8.09  | 44.18 | 8.46  | 45.85 | 8.78  | 47.73 | 9.06  | 49.43  | 9.36  | 56.94  | 63.87  |
| 11       | 4.02  | 6.16   | 112.07 | 169.54  | 1433.66 | 8.46  | 45.85 | 8.78  | 47.73 | 9.06  | 49.43 | 9.36  | 56.94  | 9.66  | 63.87  | 71.80  |
| 12       | 6.97  | 115.37 | 176.51 | 1549.03 | 8.78    | 47.73 | 9.06  | 49.43 | 9.36  | 56.94 | 63.87 | 71.80 | 79.74  | 9.96  | 71.80  | 79.74  |
| 13       | 6.28  | 107.3  | 182.79 | 1656.33 | 9.06    | 49.43 | 9.36  | 56.94 | 63.87 | 71.80 | 79.74 | 87.68 | 95.62  | 10.26 | 79.74  | 87.68  |
| 14       | 27.77 | 65.15  | 210.56 | 1721.48 | 8.18    | 56.94 | 9.66  | 63.87 | 71.80 | 79.74 | 87.68 | 95.62 | 103.58 | 10.56 | 87.68  | 95.62  |
| 15       | 25.63 | 42.58  | 236.19 | 1764.06 | 7.47    | 63.87 | 9.96  | 63.87 | 71.80 | 79.74 | 87.68 | 95.62 | 106.54 | 10.86 | 95.62  | 103.58 |
| 16       | 0.64  | 1.0    | 236.83 | 1765.86 | 7.46    | 63.87 | 9.96  | 63.87 | 71.80 | 79.74 | 87.68 | 95.62 | 109.50 | 11.16 | 103.58 | 111.74 |

TABLE A-38

TEST NO. 6-07  
INJ TEMP MAX 100 C  
INJ H2O INJ 530.0 M2 L/HR  
OUTLET PRESS PSIG 625 / 100  
PV ML 429.3  
TOT OIL G 374.5  
55 MESH SAND

| SAMPLE # | PV    | INJ    | G      | OIL     | PD      | G     | H2O   | PD    | CUM   | OIL   | CUM   | H2O   | CUM   | WOR  | OIL   | REC  |
|----------|-------|--------|--------|---------|---------|-------|-------|-------|-------|-------|-------|-------|-------|------|-------|------|
| 0        | 0     | 0      | 0      | 0       | 0       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0.00 | 0.00  | 0.00 |
| 1        | 0.23  | 73.92  | 12.24  | 73.92   | 12.24   | 73.92 | 12.24 | 0     | 0     | 0     | 0     | 0     | 0     | 0.17 | 19.74 | 0.00 |
| 2        | 0.55  | 17.09  | 119.86 | 91.01   | 132.1   | 1.45  | 24.30 | 2.47  | 27.37 | 3.34  | 30.20 | 4.30  | 33.60 | 5.20 | 36.73 | 0.00 |
| 3        | 17.58 | 11.49  | 121.29 | 102.5   | 253.39  | 2.47  | 27.37 | 3.34  | 30.20 | 4.30  | 33.60 | 5.20  | 36.73 | 5.93 | 39.70 | 0.00 |
| 4        | 1.20  | 10.59  | 124.54 | 113.09  | 377.93  | 3.34  | 30.20 | 4.30  | 33.60 | 5.20  | 36.73 | 5.93  | 39.70 | 6.66 | 42.01 | 0.00 |
| 5        | 17.59 | 12.74  | 163.24 | 125.83  | 541.17  | 4.30  | 33.60 | 5.20  | 36.73 | 5.93  | 39.70 | 6.66  | 42.01 | 7.29 | 44.56 | 0.00 |
| 6        | 2.09  | 11.74  | 174.12 | 137.57  | 715.29  | 5.20  | 36.73 | 5.93  | 39.70 | 6.66  | 42.01 | 7.29  | 44.56 | 8.09 | 47.96 | 0.00 |
| 7        | 2.52  | 11.09  | 166.23 | 148.66  | 881.52  | 5.93  | 39.70 | 6.66  | 42.01 | 7.29  | 44.56 | 8.09  | 47.96 | 8.38 | 49.97 | 0.00 |
| 8        | 2.95  | 8.65   | 165.51 | 157.31  | 1047.03 | 6.66  | 42.01 | 7.29  | 44.56 | 8.09  | 47.96 | 8.38  | 49.97 | 8.67 | 51.87 | 0.00 |
| 9        | 3.38  | 9.55   | 169.95 | 166.86  | 1216.98 | 7.29  | 44.56 | 8.09  | 47.96 | 8.38  | 49.97 | 8.67  | 51.87 | 8.92 | 52.92 | 0.00 |
| 10       | 4.00  | 12.76  | 236.77 | 179.62  | 1453.75 | 8.09  | 47.96 | 8.38  | 49.97 | 8.67  | 51.87 | 8.92  | 52.92 | 7.29 | 65.86 | 0.00 |
| 11       | 7.52  | 114.74 | 187.14 | 1568.49 | 8.38    | 49.97 | 8.67  | 51.87 | 8.92  | 52.92 | 7.29  | 65.86 | 0.00  | 7.24 | 66.42 | 0.00 |
| 12       | 7.13  | 116.76 | 194.27 | 1685.25 | 8.67    | 51.87 | 8.92  | 52.92 | 7.29  | 65.86 | 0.00  | 7.24  | 66.42 | 7.24 | 66.42 | 0.00 |
| 13       | 3.92  | 82.95  | 198.19 | 1768.2  | 8.92    | 52.92 | 7.29  | 65.86 | 0.00  | 7.24  | 66.42 | 7.24  | 66.42 | 7.24 | 66.42 | 0.00 |
| 14       | 48.46 | 30.99  | 246.65 | 1799.19 | 7.29    | 65.86 | 0.00  | 7.24  | 66.42 | 7.24  | 66.42 | 7.24  | 66.42 | 7.24 | 66.42 | 0.00 |
| 15       | 2.09  | 1.13   | 248.74 | 1800.32 | 7.24    | 66.42 | 7.24  | 66.42 | 7.24  | 66.42 | 7.24  | 66.42 | 7.24  | 7.24 | 66.42 | 0.00 |

TABLE A-39

TEST NO. 6-08  
INJ TEMP MAX 102 C  
INJ H2O INJ 530.0 M2 L/HR  
OUTLET PRESS PSIG 490 / 100  
PV ML 429.5  
TOT OIL G 378.25  
55 MESH SAND

| SAMPLE # | PV    | INJ    | G      | OIL     | PD      | G     | H2O   | PD    | CUM   | OIL   | CUM   | H2O   | CUM   | WOR  | OIL   | REC  |
|----------|-------|--------|--------|---------|---------|-------|-------|-------|-------|-------|-------|-------|-------|------|-------|------|
| 0        | 0     | 0      | 0      | 0       | 0       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0.00 | 0.00  | 0.00 |
| 1        | 0.19  | 80.92  | 40.03  | 80.92   | 40.03   | 80.92 | 40.03 | 0     | 0     | 0     | 0     | 0     | 0     | 0.49 | 21.39 | 0.00 |
| 2        | 0.43  | 14.18  | 109.05 | 95.1    | 149.08  | 1.57  | 25.14 | 3.12  | 28.84 | 4.31  | 32.76 | 5.10  | 35.89 | 5.85 | 38.78 | 0.00 |
| 3        | 0.77  | 13.99  | 191.57 | 109.09  | 340.65  | 3.12  | 28.84 | 4.31  | 32.76 | 5.10  | 35.89 | 5.85  | 38.78 | 6.53 | 41.54 | 0.00 |
| 4        | 1.20  | 14.84  | 193.88 | 123.93  | 534.53  | 4.31  | 32.76 | 5.10  | 35.89 | 5.85  | 38.78 | 6.53  | 41.54 | 7.15 | 44.18 | 0.00 |
| 5        | 1.66  | 11.82  | 157.35 | 135.75  | 691.88  | 5.10  | 35.89 | 5.85  | 38.78 | 6.53  | 41.54 | 7.15  | 44.18 | 7.68 | 46.97 | 0.00 |
| 6        | 2.08  | 10.92  | 166.25 | 146.67  | 858.13  | 5.85  | 38.78 | 6.53  | 41.54 | 7.15  | 44.18 | 7.68  | 46.97 | 7.97 | 49.15 | 0.00 |
| 7        | 2.51  | 10.47  | 167.65 | 157.14  | 1025.78 | 6.53  | 41.54 | 7.15  | 44.18 | 7.68  | 46.97 | 7.97  | 49.15 | 8.26 | 51.25 | 0.00 |
| 8        | 2.93  | 9.96   | 169.54 | 167.1   | 1195.32 | 7.15  | 44.18 | 7.68  | 46.97 | 7.97  | 49.15 | 8.26  | 51.25 | 8.49 | 53.45 | 0.00 |
| 9        | 3.39  | 10.55  | 169.2  | 177.65  | 1364.52 | 7.68  | 46.97 | 7.97  | 49.15 | 8.26  | 51.25 | 8.49  | 53.45 | 8.64 | 55.61 | 0.00 |
| 10       | 3.99  | 8.27   | 117.07 | 185.92  | 1481.59 | 7.97  | 49.15 | 8.26  | 51.25 | 8.49  | 53.45 | 8.64  | 55.61 | 7.39 | 65.23 | 0.00 |
| 11       | 7.94  | 120.57 | 193.86 | 1602.16 | 8.26    | 51.25 | 8.49  | 53.45 | 8.64  | 55.61 | 7.39  | 65.23 | 0.00  | 1.75 | 6.18  | 0.00 |
| 12       | 8.33  | 113.87 | 202.19 | 1716.03 | 8.49    | 53.45 | 8.64  | 55.61 | 7.39  | 65.23 | 0.00  | 1.75  | 6.18  | 1.75 | 6.18  | 0.00 |
| 13       | 8.15  | 102.19 | 210.34 | 1818.22 | 8.64    | 55.61 | 7.39  | 65.23 | 0.00  | 1.75  | 6.18  | 1.75  | 6.18  | 1.75 | 6.18  | 0.00 |
| 14       | 36.41 | 4.75   | 246.75 | 1822.97 | 7.39    | 65.23 | 0.00  | 1.75  | 6.18  | 1.75  | 6.18  | 1.75  | 6.18  | 1.75 | 6.18  | 0.00 |
| 15       | 1.75  | 6.18   | 248.5  | 1829.15 | 7.36    | 65.70 | 0.00  | 1.75  | 6.18  | 1.75  | 6.18  | 1.75  | 6.18  | 1.75 | 6.18  | 0.00 |

TABLE A-40

TEST NO. 6-09  
INJ TEMP MAX 102 C  
PELICAN LAKE CRUDE  
5 G/L BRINE  
55 MESH SAND

I HOT WATER + .57 PV OF 1 G/L MAOH + N2 I  
NOM H2O INJ ML/HR 530.0 M2 L/HR  
OUTLET PRESS PSIG 200 / 100  
PV ML 423.1  
TOT OIL G 374.9

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| SAMPLE # | PV INJ G | OIL PD G | H2O PD | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|----------|----------|--------|---------|---------|---------|---------|
| 0        | 0        | 0        | 0      | 0       | 0       | 0.00    | 0.00    |
| 1        | 0.29     | 65.02    | 44.51  | 65.02   | 44.51   | 0.68    | 17.34   |
| 2        | 0.62     | 22.08    | 114.27 | 87.1    | 158.78  | 1.82    | 23.23   |
| 3        | 0.97     | 13.49    | 123.36 | 100.59  | 282.14  | 2.80    | 26.83   |
| 4        | 1.31     | 10.23    | 132.2  | 110.82  | 414.34  | 3.74    | 29.56   |
| 5        | 1.77     | 12.22    | 172.83 | 123.04  | 587.17  | 4.77    | 32.82   |
| 6        | 2.20     | 11.35    | 160.24 | 134.39  | 747.41  | 5.56    | 35.85   |
| 7        | 2.64     | 12.38    | 168.05 | 146.77  | 915.46  | 6.24    | 39.15   |
| 8        | 3.09     | 12.24    | 168.81 | 159.01  | 1084.27 | 6.82    | 42.41   |
| 9        | 3.55     | 10.79    | 176.64 | 169.8   | 1260.91 | 7.43    | 45.29   |
| 10       | 3.77     | 5.36     | 80.82  | 175.16  | 1341.73 | 7.66    | 46.72   |
| 11       |          | 6.56     | 116.12 | 181.72  | 1457.85 | 8.02    | 48.47   |
| 12       |          | 6.68     | 113.37 | 188.4   | 1571.22 | 8.34    | 50.25   |
| 13       |          | 19.97    | 71.03  | 208.37  | 1642.25 | 7.88    | 55.58   |
| 14       |          | 19.42    | 54.68  | 227.79  | 1696.93 | 7.45    | 60.76   |
| 15       |          | 1.7      | 13.22  | 229.49  | 1710.15 | 7.45    | 61.21   |

TABLE A-41

TEST NO. 6-10  
INJ TEMP MAX 102 C  
PELICAN LAKE CRUDE  
5 G/L BRINE  
55 MESH SAND

I HOT WATER + .57 PV OF 1 G/L TBS + N2 I  
NOM H2O INJ ML/HR 530.0 M2 L/HR  
OUTLET PRESS PSIG 275 / 100  
PV ML 424.4  
TOT OIL G 375.5

36

| SAMPLE # | PV INJ G | OIL PD G | H2O PD | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|----------|----------|--------|---------|---------|---------|---------|
| 0        | 0        | 0        | 0      | 0       | 0       | 0.00    | 0.00    |
| 1        | 0.30     | 69.31    | 48.68  | 69.31   | 48.68   | 0.70    | 18.46   |
| 2        | 0.63     | 18.83    | 114.83 | 88.14   | 163.51  | 1.86    | 23.47   |
| 3        | 1.06     | 16.16    | 162.67 | 104.3   | 326.18  | 3.13    | 27.78   |
| 4        | 1.51     | 12.86    | 168.76 | 117.16  | 494.94  | 4.22    | 31.20   |
| 5        | 1.94     | 13.19    | 161.65 | 130.35  | 656.59  | 5.04    | 34.71   |
| 6        | 2.33     | 11.61    | 145.16 | 141.96  | 801.75  | 5.65    | 37.81   |
| 7        | 2.76     | 13.08    | 162.49 | 155.04  | 964.24  | 6.22    | 41.29   |
| 8        | 3.20     | 13.14    | 172.15 | 168.18  | 1136.39 | 6.76    | 44.79   |
| 9        | 3.65     | 11.12    | 163.8  | 179.3   | 1300.19 | 7.25    | 47.75   |
| 10       | 4.00     | 9.41     | 137.24 | 188.71  | 1437.43 | 7.62    | 50.26   |
| 11       |          | 5.2      | 72.59  | 193.91  | 1510.02 | 7.79    | 51.64   |
| 12       |          | 10.27    | 157.06 | 204.18  | 1667.08 | 8.16    | 54.38   |
| 13       |          | 5.25     | 103.88 | 209.43  | 1770.96 | 8.46    | 55.77   |
| 14       |          | 25.74    | 26.92  | 235.17  | 1797.88 | 7.65    | 62.63   |
| 15       |          | 10.78    | 4.14   | 245.95  | 1802.02 | 7.33    | 65.50   |

TABLE A-42

TEST NO. 6-11 I HOT WATER + .57 PV OF 1 G/L MAOH + N2 )  
 INJ TEMP MAX 103 C NOM H2O INJ ML/HR 530.0 M2 L/HR  
 BUFFALO COULEE CRUDE OUTLET PRESS PSIG 410 / 100  
 5 G/L BRINE PV ML 424.4  
 55 MESH SAND TOT OIL G 371.4

| SAMPLE # | PV   | INJ   | G      | OIL    | PD      | G     | H2O   | PD    | CUM   | OIL   | CUM   | H2O   | CUM   | WOR   | OIL   | REC  |
|----------|------|-------|--------|--------|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|
|          | 0    | 0     | 0      | 0      | 0       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0.00  | 0.00  | 0.00 |
| 1        | 0.39 | 74.88 | 71.81  | 74.88  | 71.81   | 74.88 | 71.81 | 74.88 | 71.81 | 74.88 | 71.81 | 74.88 | 71.81 | 0.96  | 20.16 | 36   |
| 2        | 0.76 | 15.89 | 133.42 | 90.77  | 205.23  | 2.26  | 24.44 | 3.29  | 27.27 | 30.04 | 32.50 | 35.01 | 37.41 | 41.00 | 43.64 |      |
| 3        | 1.09 | 10.52 | 128.44 | 101.29 | 333.67  | 4.32  | 30.04 | 5.11  | 32.50 | 35.01 | 37.41 | 41.00 | 43.64 | 47.86 | 49.64 |      |
| 4        | 1.48 | 10.29 | 148.69 | 111.58 | 482.36  | 5.84  | 35.01 | 6.61  | 37.41 | 41.00 | 43.64 | 47.86 | 49.64 | 51.43 | 53.78 |      |
| 5        | 1.53 | 9.14  | 134.42 | 120.72 | 616.78  | 5.84  | 35.01 | 6.61  | 37.41 | 41.00 | 43.64 | 47.86 | 49.64 | 51.43 | 53.78 |      |
| 6        | 2.20 | 9.3   | 142.2  | 130.02 | 758.98  | 5.84  | 35.01 | 6.61  | 37.41 | 41.00 | 43.64 | 47.86 | 49.64 | 51.43 | 53.78 |      |
| 7        | 2.61 | 8.91  | 158.68 | 138.93 | 917.66  | 6.61  | 37.41 | 7.38  | 41.00 | 43.64 | 47.86 | 49.64 | 51.43 | 53.78 | 55.09 |      |
| 8        | 3.14 | 13.34 | 206.01 | 152.27 | 1123.67 | 7.38  | 41.00 | 8.17  | 47.86 | 49.64 | 51.43 | 53.78 | 55.09 | 57.84 | 59.91 |      |
| 9        | 3.57 | 9.81  | 162.61 | 162.08 | 1286.28 | 7.94  | 43.64 | 8.17  | 47.86 | 49.64 | 51.43 | 53.78 | 55.09 | 57.84 | 59.91 |      |
| 10       | 4.01 | 15.69 | 165.68 | 177.77 | 1451.96 | 8.17  | 47.86 | 8.52  | 49.64 | 51.43 | 53.78 | 55.09 | 57.84 | 59.91 | 61.00 |      |
| 11       |      | 6.6   | 119.38 | 184.37 | 1571.34 | 8.52  | 49.64 | 8.80  | 51.43 | 53.78 | 55.09 | 57.84 | 59.91 | 61.00 | 62.10 |      |
| 12       |      | 6.63  | 110.1  | 191    | 1681.44 | 8.80  | 51.43 | 9.02  | 48.75 | 46.97 | 48.93 | 50.09 | 52.84 | 54.84 | 56.84 |      |
| 13       |      | 8.73  | 79.83  | 199.73 | 1761.27 | 9.02  | 48.75 | 9.25  | 46.97 | 48.93 | 50.09 | 52.84 | 54.84 | 56.84 | 58.84 |      |
| 14       |      | 38.94 | 28.03  | 238.67 | 1789.3  | 7.50  | 64.26 | 7.7   | 3.33  | 8.33  | 8.51  | 8.61  | 8.61  | 8.61  | 8.61  |      |
| 15       |      | 2.84  | 5.95   | 241.51 | 1795.25 | 7.43  | 65.03 |       |       |       |       |       |       |       |       |      |

TABLE A-43

TEST NO. 6-12 I HOT WATER + .57 PV OF 1 G/L TRS + N2 )  
 INJ TEMP MAX 105 C NOM H2O INJ ML/HR 530.0 M2 L/HR  
 BUFFALO COULEE CRUDE OUTLET PRESS PSIG 300 / 100  
 5 G/L BRINE PV ML 425.2  
 55 MESH SAND TOT OIL G 371.7

| SAMPLE # | PV   | INJ   | G      | OIL    | PD      | G     | H2O   | PD    | CUM   | OIL   | CUM   | H2O   | CUM   | WOR   | OIL   | REC  |
|----------|------|-------|--------|--------|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|
|          | 0    | 0     | 0      | 0      | 0       | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 0.00  | 0.00  | 0.00 |
| 1        | 0.21 | 55.87 | 27.84  | 55.87  | 27.84   | 55.87 | 27.84 | 55.87 | 27.84 | 55.87 | 27.84 | 55.87 | 27.84 | 0.50  | 15.03 | 36   |
| 2        | 0.54 | 19.04 | 119.77 | 74.91  | 147.61  | 1.97  | 20.15 | 2.94  | 24.05 | 27.86 | 30.97 | 34.01 | 36.90 | 39.68 | 42.40 |      |
| 3        | 0.94 | 14.5  | 154.15 | 89.41  | 301.76  | 3.38  | 24.05 | 4.32  | 27.86 | 30.97 | 34.01 | 36.90 | 39.68 | 42.40 | 44.75 |      |
| 4        | 1.50 | 14.15 | 217.09 | 103.56 | 518.85  | 5.01  | 27.86 | 5.91  | 30.97 | 34.01 | 36.90 | 39.68 | 42.40 | 44.75 | 46.97 |      |
| 5        | 1.91 | 11.54 | 161.71 | 115.1  | 680.56  | 5.91  | 30.97 | 6.77  | 34.01 | 36.90 | 39.68 | 42.40 | 44.75 | 46.97 | 48.93 |      |
| 6        | 2.36 | 11.32 | 175.82 | 126.42 | 856.38  | 6.77  | 34.01 | 7.39  | 36.90 | 39.68 | 42.40 | 44.75 | 46.97 | 48.93 | 50.09 |      |
| 7        | 2.77 | 10.74 | 157.4  | 137.16 | 1013.78 | 7.39  | 36.90 | 8.00  | 39.68 | 42.40 | 44.75 | 46.97 | 48.93 | 50.09 | 52.84 |      |
| 8        | 3.19 | 10.32 | 165.47 | 147.48 | 1179.25 | 8.00  | 39.68 | 8.58  | 42.40 | 44.75 | 46.97 | 48.93 | 50.09 | 52.84 | 54.84 |      |
| 9        | 3.64 | 10.13 | 172.99 | 157.61 | 1352.24 | 8.58  | 42.40 | 9.02  | 44.75 | 46.97 | 48.93 | 50.09 | 52.84 | 54.84 | 56.84 |      |
| 10       | 4.02 | 8.74  | 147.7  | 166.35 | 1499.94 | 9.02  | 44.75 | 9.25  | 46.97 | 48.93 | 50.09 | 52.84 | 54.84 | 56.84 | 58.84 |      |
| 11       |      | 8.24  | 114.8  | 174.59 | 1614.74 | 9.25  | 46.97 | 9.53  | 48.93 | 50.09 | 52.84 | 54.84 | 56.84 | 58.84 | 60.84 |      |
| 12       |      | 7.29  | 118.11 | 181.88 | 1732.85 | 9.53  | 48.93 | 9.80  | 50.09 | 52.84 | 54.84 | 56.84 | 58.84 | 60.84 | 62.84 |      |
| 13       |      | 4.29  | 91.28  | 186.17 | 1824.13 | 9.80  | 50.09 | 10.09 | 52.84 | 54.84 | 56.84 | 58.84 | 60.84 | 62.84 | 64.84 |      |
| 14       |      | 28.83 | 27.05  | 215    | 1851.18 | 8.61  | 57.84 |       |       |       |       |       |       |       |       |      |
| 15       |      | 7.7   | 3.33   | 222.7  | 1854.51 | 8.33  | 59.91 |       |       |       |       |       |       |       |       |      |

TABLE A-44

TEST NO. 6-13  
INJ TEMP MAX 100 C  
BUFFALO COULEE CRUDE  
5 G/L BRINE  
55 MESH SAND

( HOT WATER + .57 PV OF 3 G/L TRS + H2 )  
NOM H2O INJ ML/HR 530.0 H2 L/HR  
OUTLET PRESS PSIG 350 / 100  
PV ML 422.3  
TOT OIL G 369.7

36

| SAMPLE # | PV INJ G | OIL PD G | H2O PD G | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|----------|----------|----------|---------|---------|---------|---------|
| 0        | 0        | 0        | 0        | 0       | 0       | 0.00    | 0.00    |
| 1        | 0.39     | 68.28    | 84.11    | 68.28   | 84.11   | 1.23    | 18.47   |
| 2        | 0.73     | 13.22    | 124.07   | 81.5    | 208.18  | 2.55    | 22.04   |
| 3        | 1.15     | 13.21    | 157.89   | 94.71   | 366.07  | 3.87    | 25.62   |
| 4        | 1.57     | 10.94    | 160.74   | 105.65  | 526.81  | 4.99    | 28.58   |
| 5        | 2.00     | 11.34    | 161.38   | 116.99  | 688.19  | 5.88    | 31.64   |
| 6        | 2.46     | 11.74    | 178.18   | 128.73  | 866.37  | 6.73    | 34.82   |
| 7        | 3.01     | 13.04    | 208.43   | 141.77  | 1074.8  | 7.58    | 38.35   |
| 8        | 3.33     | 9.09     | 123.43   | 150.86  | 1198.23 | 7.94    | 40.81   |
| 9        | 3.66     | 7.72     | 125.56   | 158.58  | 1323.79 | 8.35    | 42.89   |
| 10       | 4.01     | 8.19     | 125.73   | 166.77  | 1449.52 | 8.69    | 45.11   |
| 11       |          | 6.86     | 113.66   | 173.63  | 1563.18 | 9.00    | 46.97   |
| 12       |          | 6.89     | 110.55   | 180.52  | 1673.73 | 9.27    | 48.83   |
| 13       |          | 4.09     | 87.15    | 184.61  | 1760.88 | 9.54    | 49.94   |
| 14       |          | 32.73    | 37.31    | 217.34  | 1798.19 | 8.27    | 58.79   |
| 15       |          | 5.1      | 2.21     | 222.44  | 1800.4  | 8.09    | 60.17   |

TABLE A-45

TEST NO. 6-14  
INJ TEMP MAX 101 C  
BUFFALO COULEE CRUDE  
5 G/L BRINE  
55 MESH SAND

( HOT WATER + .57 PV OF 5 G/L MACH + H2 )  
NOM H2O INJ ML/HR 530.0 H2 L/HR  
OUTLET PRESS PSIG 390 / 100  
PV ML 424.6  
TOT OIL G 372.1

36

| SAMPLE # | PV INJ G | OIL PD G | H2O PD G | CUM OIL | CUM H2O | CUM WOR | OIL REC |
|----------|----------|----------|----------|---------|---------|---------|---------|
| 0        | 0        | 0        | 0        | 0       | 0       | 0.00    | 0.00    |
| 1        | 0.33     | 67.16    | 58.84    | 67.16   | 58.84   | 0.88    | 18.05   |
| 2        | 0.66     | 17.04    | 118.62   | 84.2    | 177.46  | 2.11    | 22.63   |
| 3        | 1.09     | 14.75    | 163.12   | 98.95   | 340.58  | 3.44    | 26.59   |
| 4        | 1.70     | 13.31    | 236.62   | 112.26  | 577.2   | 5.14    | 30.17   |
| 5        | 2.00     | 8.2      | 109      | 120.46  | 686.2   | 5.70    | 32.37   |
| 6        | 2.43     | 11.72    | 164.14   | 132.18  | 850.34  | 6.43    | 35.52   |
| 7        | 2.86     | 10.67    | 160.97   | 142.85  | 1011.31 | 7.08    | 38.39   |
| 8        | 3.32     | 10.83    | 176.7    | 153.68  | 1188.01 | 7.73    | 41.30   |
| 9        | 3.79     | 10.88    | 180.65   | 164.56  | 1368.66 | 8.32    | 44.22   |
| 10       | 4.01     | 5.74     | 81.22    | 170.3   | 1449.88 | 8.51    | 45.77   |
| 11       |          | 7.22     | 119.55   | 177.52  | 1569.43 | 8.84    | 47.71   |
| 12       |          | 2.65     | 122.6    | 180.17  | 1692.03 | 9.39    | 48.42   |
| 13       |          | 33.5     | 57.95    | 213.67  | 1749.98 | 8.19    | 57.42   |
| 14       |          | 57.84    | 7.37     | 271.51  | 1757.35 | 6.47    | 72.97   |
| 15       |          | 1.39     | 1.57     | 272.9   | 1758.92 | 6.45    | 73.34   |

TABLE A-46

| TEST NO. 6-15 [ HOT WATER + .57 PV OF 5 G/L WASH + M2 ] |      |       |        |        |    |   |         |    |        |     |         |     |      |       |     | 36   |
|---------------------------------------------------------|------|-------|--------|--------|----|---|---------|----|--------|-----|---------|-----|------|-------|-----|------|
| INJ TEMP MAX 105 C NOM H2O INJ ML/HR 530.0 M2 L/HR      |      |       |        |        |    |   |         |    |        |     |         |     |      |       |     |      |
| BUFFALO COULEE CRUDE OUTLET PRESS PSIG 400 / 100        |      |       |        |        |    |   |         |    |        |     |         |     |      |       |     |      |
| 5 G/L BRINE PV ML 423.5                                 |      |       |        |        |    |   |         |    |        |     |         |     |      |       |     |      |
| 55 NEEN SAND TOT OIL G 368                              |      |       |        |        |    |   |         |    |        |     |         |     |      |       |     |      |
| SAMPLE #                                                | PV   | INJ   | G      | OIL    | PD | G | H2O     | PD | CUM    | OIL | CUM     | H2O | CUM  | WOR   | OIL | REC  |
|                                                         | 0    |       |        |        | 0  |   | 0       |    | 0      |     |         | 0   |      | 0.00  |     | 0.00 |
| 1                                                       | 0.44 | 62.04 | 105.65 | 62.04  |    |   | 105.65  |    | 62.04  |     | 105.65  |     | 1.70 | 16.86 |     |      |
| 2                                                       | 0.77 | 15.45 | 119.74 | 77.49  |    |   | 225.39  |    | 77.49  |     | 225.39  |     | 2.91 | 21.06 |     |      |
| 3                                                       | 1.12 | 13.06 | 131.84 | 90.55  |    |   | 357.23  |    | 90.55  |     | 357.23  |     | 3.95 | 24.61 |     |      |
| 4                                                       | 1.62 | 13.42 | 184.39 | 103.97 |    |   | 541.62  |    | 103.97 |     | 541.62  |     | 5.21 | 28.25 |     |      |
| 5                                                       | 2.07 | 10.91 | 174.22 | 114.88 |    |   | 715.84  |    | 114.88 |     | 715.84  |     | 6.23 | 31.22 |     |      |
| 6                                                       | 2.48 | 9.76  | 153.94 | 124.64 |    |   | 869.78  |    | 124.64 |     | 869.78  |     | 6.98 | 33.87 |     |      |
| 7                                                       | 2.85 | 9.85  | 139.52 | 134.49 |    |   | 1009.3  |    | 134.49 |     | 1009.3  |     | 7.50 | 36.55 |     |      |
| 8                                                       | 2.06 | 9.28  | 149.65 | 143.77 |    |   | 1158.95 |    | 143.77 |     | 1158.95 |     | 8.06 | 39.07 |     |      |
| 9                                                       | 3.71 | 13.64 | 179.72 | 157.41 |    |   | 1338.67 |    | 157.41 |     | 1338.67 |     | 8.50 | 42.77 |     |      |
| 10                                                      | 4.05 | 5.09  | 114.91 | 162.5  |    |   | 1453.58 |    | 162.5  |     | 1453.58 |     | 8.95 | 44.16 |     |      |
| 11                                                      |      | 7.22  | 117.91 | 169.72 |    |   | 1571.49 |    | 169.72 |     | 1571.49 |     | 9.26 | 46.12 |     |      |
| 12                                                      |      | 6.92  | 120.84 | 176.64 |    |   | 1692.03 |    | 176.64 |     | 1692.03 |     | 9.58 | 48.00 |     |      |
| 13                                                      |      | 24.43 | 66.23  | 201.07 |    |   | 1758.26 |    | 201.07 |     | 1758.26 |     | 8.74 | 54.64 |     |      |
| 14                                                      |      | 10.47 | 47.67  | 211.54 |    |   | 1805.93 |    | 211.54 |     | 1805.93 |     | 8.54 | 57.48 |     |      |
| 15                                                      |      | 2.02  | 16.35  | 213.56 |    |   | 1822.28 |    | 213.56 |     | 1822.28 |     | 8.53 | 58.03 |     |      |

TABLE A-47

| TEST NO. 6-16 [ HOT WATER + .57 PV OF 3 G/L TRS + M2 ] |      |       |        |        |         |      |       |    |     |     |     |     |     |      |       | 36   |
|--------------------------------------------------------|------|-------|--------|--------|---------|------|-------|----|-----|-----|-----|-----|-----|------|-------|------|
| INJ TEMP MAX 102 C NOM H2O INJ ML/HR 530.0 M2 L/HR     |      |       |        |        |         |      |       |    |     |     |     |     |     |      |       |      |
| PELICAN LAKE CRUDE OUTLET PRESS PSIG 275 / 100         |      |       |        |        |         |      |       |    |     |     |     |     |     |      |       |      |
| 5 G/L BRINE PV ML 422.4                                |      |       |        |        |         |      |       |    |     |     |     |     |     |      |       |      |
| 55 MEEN SAND TOT OIL G 370.4                           |      |       |        |        |         |      |       |    |     |     |     |     |     |      |       |      |
| SAMPLE #                                               | PV   | INJ   | G      | OIL    | PD      | G    | H2O   | PD | CUM | OIL | CUM | H2O | CUM | WOR  | OIL   | REC  |
|                                                        | 0    |       |        |        | 0       |      | 0     |    | 0   |     |     | 0   |     | 0.00 |       | 0.00 |
| 1                                                      | 0.35 | 60.44 | 77.48  | 60.44  | 77.48   | 1.28 | 16.32 |    |     |     |     |     |     | 1.28 | 16.32 |      |
| 2                                                      | 0.67 | 18.07 | 115.74 | 78.51  | 193.22  | 2.46 | 21.20 |    |     |     |     |     |     | 2.46 | 21.20 |      |
| 3                                                      | 1.11 | 15.85 | 161.35 | 94.36  | 354.57  | 3.76 | 25.48 |    |     |     |     |     |     | 3.76 | 25.48 |      |
| 4                                                      | 1.50 | 13.02 | 127    | 107.38 | 481.57  | 4.48 | 28.99 |    |     |     |     |     |     | 4.48 | 28.99 |      |
| 5                                                      | 1.89 | 16.57 | 169.78 | 123.95 | 651.35  | 5.25 | 33.46 |    |     |     |     |     |     | 5.25 | 33.46 |      |
| 6                                                      | 2.42 | 15.04 | 206.24 | 138.99 | 857.59  | 6.17 | 37.52 |    |     |     |     |     |     | 6.17 | 37.52 |      |
| 7                                                      | 2.72 | 8.37  | 114.74 | 147.36 | 972.33  | 6.60 | 39.78 |    |     |     |     |     |     | 6.60 | 39.78 |      |
| 8                                                      | 3.04 | 8.16  | 123.64 | 155.52 | 1095.97 | 7.05 | 41.99 |    |     |     |     |     |     | 7.05 | 41.99 |      |
| 9                                                      | 3.48 | 10.45 | 171.21 | 165.97 | 1267.18 | 7.63 | 44.81 |    |     |     |     |     |     | 7.63 | 44.81 |      |
| 10                                                     | 4.01 | 11.53 | 212.43 | 177.5  | 1479.61 | 8.34 | 47.92 |    |     |     |     |     |     | 8.34 | 47.92 |      |
| 11                                                     |      | 7.66  | 159.05 | 185.16 | 1638.66 | 8.85 | 49.99 |    |     |     |     |     |     | 8.85 | 49.99 |      |
| 12                                                     |      | 5.1   | 100.37 | 190.26 | 1739.03 | 9.14 | 51.37 |    |     |     |     |     |     | 9.14 | 51.37 |      |
| 13                                                     |      | 4.78  | 91.54  | 195.04 | 1830.57 | 9.39 | 52.66 |    |     |     |     |     |     | 9.39 | 52.66 |      |
| 14                                                     |      | 24.39 | 46.17  | 219.43 | 1876.74 | 8.55 | 59.24 |    |     |     |     |     |     | 8.55 | 59.24 |      |
| 15                                                     |      | 2.58  | 3.21   | 222.01 | 1879.95 | 8.47 | 59.94 |    |     |     |     |     |     | 8.47 | 59.94 |      |